1/5/1990

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PHASE I REMEDIAL INVESTIGATION

Terminal 91 Facility

Seattle, Washington

Prepared for:

Pacific Northern Oil

Converse Project No. 89-45527-02

January 5, 1990

Converse GES Geoenvironmental Services

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89-45527-02

Pacific Northern Oil
North Tower - Suite 200
100 West Harrison Plaza
Seattle, Washington 98119

Attention: Mr. George Markwood

Subject: Transmittal of draft Phase I Remedial Investigation and Proposal for Free Product Extraction System

Gentlemen:

Our draft Phase I Remedial Investigation report and a draft scope of work and cost proposal for a free product extraction system accompany this letter. Recommendations are provided in the report for a free product extraction system, pump testing of the system, obtaining groundwater and contaminant data from the Port of Seattle for their leaking underground tank investigation at the north end of the cold storage warehouse, and continued monitoring of the existing eight-well network. Pump test data and the additional monitoring data could be used to site additional monitoring wells, if appropriate. A final Phase I remedial investigation report will be prepared following receipt of your review comments.

The draft scope of work and cost proposal for the product extraction system presents two system options. We present this proposal as a basis for discussion. We have enjoyed working on this report for you and look forward to meeting with you on the free product extraction system.

Sincerely,

CONVERSE GES

Erick W. Miller

Erick W. Miller
Project Hydrogeologist

Ronald E. Guest

Ronald E. Guest, P.E.
Executive Vice President

EWM2/REG/kpp

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EXECUTIVE SUMMARY

This report presents the results of our Phase I Remedial Investigation at Pacific Northern Oil's Terminal 91 facility. Results of previous investigations at Terminal 91 by Hart Crowser (September 11, 1989) and Converse GES (November 22, 1989) have been incorporated into this report. In the preliminary hydrogeologic assessment, one round of groundwater samples obtained from the four existing wells were analyzed for total petroleum hydrocarbons (TPH). Groundwater level measurements were taken throughout a 24-hour period to determine the tidal influence on groundwater gradient. Groundwater and chemical data were used to site four additional monitoring wells installed as part of the Phase I Remedial Investigation.

Four additional monitoring wells were installed on November 29 and 30, 1989 to a nominal depth of 17 feet. Soil samples were obtained at 2.5-foot intervals from the monitoring well borings and field screened with a photoionization detector. Three samples from each boring were selected for laboratory analysis based on field screening and proximity to the water table. Following well development, groundwater samples were collected from all eight wells and submitted to Laucks Testing Laboratories, Inc. for TPH analysis.

Results indicate the presence of floating hydrocarbons in monitoring wells MW-3 and MW-104. Measured product thicknesses in MW-3 range from 0.24 to 0.69 foot. The change in product thickness appears to be a function of tidal fluctuations where the product layer increases with a declining tide. A thin layer of floating hydrocarbons, 0.01 foot thick, was measured in MW-104. The two product lenses do not appear to be connected. The areal extent of free product at MW-3 is constrained by monitoring wells MW-102, MW-11, MW-6, and MW-2. The eastern extent is constrained by the retaining wall. Using a porosity of 20 percent, a free product areal extent of 11,450 square feet, and a true product thickness range of 0.02 to 0.08 foot, an estimated 340 to 1,370 gallons

of free product are present on site. The spatial separation of the two product lenses may indicate two sources or a physical discontinuity between the wells such as a bulkhead.

With the exception of the boring east of the east retaining wall, TPH-contaminated soils were found throughout the area of investigation. Elevated levels of total petroleum hydrocarbons in soils occur predominantly at the water table and slightly above. Boring B-4, installed in an earlier investigation on the east side of the bulkhead, had TPH concentrations below the detection limit at the water table indicating the bulkhead serves as a barrier to product migration. Product entering the short fill lagoon appears to be seeping through cracks in the bulkhead or under the bulkhead. TPH concentrations in soils generally increase from west to east with the highest concentrations along the east side of the bulkhead.

Monitoring wells exceeding the Department of Ecology cleanup guidelines of 15 ppm for groundwater include wells MW-3 and MW-101. Monitoring well MW-2 had a TPH level equal to the cleanup guideline during the October 30, 1989 sample event. Monitoring well MW-104, which had a 0.01 foot layer of free product prior to well development, had a TPH concentration of 6.2 ppm. TPH concentrations were significantly lower in wells obtained after well development.

Additional excavation along the pipeline could be used to locate unknown branches of the pipeline, in the vicinity of MW-3, which may be a potential source. If additional excavation is not planned, ground penetrating radar could be used to locate possible buried pipeline splays.

A large-diameter recovery well or sump in conjunction with a product recovery system is recommended in the vicinity of MW-3 for extraction of floating hydrocarbons. This system would be used for interim product removal and could be expanded at a later date pending further definition of the contamination. Once the product recovery system is in place, a pump test is recommended to determine the continuity of the aquifer and the possible connection between monitor wells and product lenses.

At present, the Port of Seattle is investigating a leaking underground storage tank at the north end of the cold storage warehouse. Groundwater level and chemical data should be obtained from this investigation.

An additional round of groundwater samples from the eight existing monitoring wells should be obtained to more adequately characterize the TPH concentrations in groundwater. This data, in conjunction with data from the cold warehouse storage tank investigation and pump test, should be used to site additional monitoring wells, if appropriate.

INTRODUCTION

This report presents the results of our Phase I remedial investigation for the petroleum spill at Port of Seattle Terminal 91. Results of previous investigations at Terminal 91 by Hart Crowser (September 11, 1989) and Converse GES (November 22, 1989) have been incorporated into this report. The report includes a summary of field and laboratory data, interpretation of groundwater flow and contaminant data, and conclusions and recommendations for free product removal and additional site characterization. These services are provided in accordance with our proposal dated October 12, 1989.

Terminal 91 is located at the north end of Elliott Bay at the Magnolia Bridge crossing, as shown in Figure 1. Pacific Northern Oil operates a ship refueling facility at Terminal 91. Chemical Processors, Inc. (Chempro) holds the master lease to the refueling facility and subleases to Pacific Northern Oil.

An initial investigation of source of petroleum seepage into the short fill lagoon (Lake Jacobs) was conducted by Hart Crowser (Oil Seepage Investigation, Short Fill Pond, Terminal 91, September 11, 1989) under contract to the Port of Seattle. Subsurface explorations in that investigation consisted of eleven soil borings, four of which were completed as monitoring wells. Soil samples were obtained from the borings at 2.5-foot intervals and analyzed for fuel mixtures using a gas chromatograph coupled with a flame ionization detector (GC/FID). Selected samples were sent to an analytical testing laboratory for confirmation of the petroleum screening and for analysis of volatile and semi-volatile compounds. Elevated concentrations of petroleum hydrocarbons were detected in all but one of the soil borings. Petroleum hydrocarbon concentrations were less than the detection limit at boring B-4, located in the short-fill area, just east of a concrete retaining wall. No volatile or semi-volatile compounds were detected. Subsurface data and results of the GC/FID petroleum screen have been incorporated into this report. No groundwater samples were analyzed in the Hart Crowser Oil Seepage Investigation.

Converse GES performed a preliminary hydrogeologic investigation to determine chemical gradients, groundwater flow direction and tidal influence on groundwater flow (Converse GES, November 22, 1989, Preliminary Hydrogeologic Assessment Report, Terminal 91 Facility, Seattle). This data was used to site four additional monitoring wells for the Phase I Remedial Investigation. Data from this investigation has also been incorporated into this report.

The purpose of this investigation was to define the extent of groundwater contamination at Terminal 91, to the extent feasible using the data collected from the four additional monitoring wells, and to make specific recommendations for additional monitoring wells and a product recovery system as necessary.

METHODS OF INVESTIGATION

On October 30, 1989, the four existing 2-inch diameter monitoring wells (MW-2, MW-3, MW-6, and MW-11) at Pacific Northern Oil's Terminal 91 site were sampled. The monitoring well locations are shown on Figure 2. Prior to sampling, three to five casing volumes were removed from each well to ensure fresh formation water at the time of sampling. Samples were placed in an ice chest chilled with blue ice and delivered to Laucks Testing Laboratories in Seattle for analysis of total petroleum hydrocarbons (TPH) using EPA method 418.1.

Groundwater levels were measured throughout the duration of one tide cycle to determine if diurnal fluctuations in tide would have an impact on the direction and gradient of groundwater flow. A Terra-8 datalogger utilizing pressure transducers in the 0 to 5 psi range was programmed to take measurements of groundwater levels from monitoring wells MW-2, MW-3 and MW-6. After obtaining initial hand measurements of the static groundwater depth, the pressure transducer probes were lowered into the respective monitoring wells to a depth of approximately 5 feet below the water table. The duration of the groundwater level measurements was

from Thursday, 11/09/89 11:23 a.m. until Friday, 11/10/89 2:04 p.m. Three high tides and two low tides occurred during the measurement period.

Groundwater and chemical data were summarized in a preliminary hydrogeologic assessment report dated November 22, 1989. The data was used to site four additional monitoring wells to define the extent of hydrocarbon contamination in a Phase I Remedial Investigation. Four monitoring wells, MW-101 through MW-104, were used to explore subsurface and groundwater conditions and collect samples for chemical testing. These wells were drilled to a nominal depth of 17 feet. The well locations are shown in Figure 2.

Port of Seattle engineering drawings were carefully reviewed prior to drilling to determine the location of buried utility lines. In addition, the underground extensions of utilities identified in the field were traced using a Goldak pipe-cable locator.

Soil samples from the four monitoring well borings were obtained at 2½-foot intervals using a Standard Penetration Test (SPT) and a split spoon. Three soil samples from each boring were selected based on field screening with a photoionization detector and proximity to the water table. Samples were placed in a pre-cooled ice chest and transported to Laucks Testing Laboratories for TPH analysis using EPA method 418.1. Chain-of-custody procedures were followed for all sampling and transportation. Complete details of drilling and sampling methods are presented in Appendix A with the boring logs and well completion diagrams.

Each of the four borings were completed with a 4-inch diameter monitoring well. The wells were cased with schedule 40 PVC blank casing and 10 feet of machine slotted PVC screen with 0.01-inch slot size. A filter pack was placed from the bottom of the boring to 2 feet above the screened interval. A 2-foot bentonite seal was placed above the filter pack, and cement grout was used to seal the remaining annular space. All wells were finished off with flush mounts. Details of well construction and well completion diagrams are presented in Appendix A.

On December 6 and 7, 1989, the four existing monitoring wells and the four new wells were developed by bailing and sampled. Samples were obtained from the eight-well monitoring well network with a Teflon bailer and transported to Laucks Testing Laboratories for TPH analysis by EPA method 418.1. Details of well development procedure and groundwater sampling are presented in Appendix B.

Subsurface Conditions

Subsurface conditions at Terminal 91 consist of approximately 5 feet of fill material overlying native sands, gravelly sands and sandy gravels of probable marine origin. The fill material consisted of a dry, medium dense, medium-size sand with pea-size gravel.

A moist to saturated, gray, medium to coarse sand was encountered immediately beneath the fill. In places, minor gravel was present within the sand. Small angular broken pieces of shell fragments were observed in this unit, suggesting a marine origin. Geologic cross section A-A' (Figure 3) and geologic cross section B-B' (Figure 4) present north-south and east-west cross sections, respectively, through the site. The cross section lines are shown in Figure 2. The sandy fill material and native sands are depicted as a single unit in the cross sections and designated as gravelly sand and sand.

A saturated, gray, sandy gravel was located beneath the sand and gravelly sand deposits. This layer also contained a minor percentage of shell fragments. The sandy gravel layer depicted in Figure 3 thickens toward the north and thins toward the south of the site.

Tidal Response and Groundwater Flow Direction

Hydrographs of the static water level elevations collected from MW-2 and MW-6 during the tidal response investigation are shown on Figure 5. The response of the groundwater level to the high tide on 11/9/89 at 1:09 p.m. and on 11/10/89 at 2:14 a.m. is shown by the peaks of the graph

occurring at approximately 200 minutes and 900 minutes, respectively. Likewise, the troughs of the plot occurring at approximately 550 minutes and 1200 minutes represent the groundwater levels during the low tide on 11/9/89 at 7:58 p.m. and on 11/10/89 at 7:43 a.m. The total net water level fluctuation was 0.23 foot for MW-6 and 0.24 foot for MW-2. A maximum water level fluctuation of 0.34 foot was recorded in MW-11. The response of the groundwater level at the site is in phase with tidal fluctuations. In other words, the highest measured groundwater levels correspond to the time period of high tide and the lowest measured groundwater levels correspond to the time period of low tide.

The gradient inducing groundwater flow, using data collected during one tidal cycle from monitoring wells MW-2, MW-3 and MW-6, is shown on Figure 6. Table 1 lists static water level elevations used in Figure 2 as well as groundwater level measurements made on December 6, 1989. The apparent direction of groundwater flow during the tidal cycle measured between November 9, 1989 and November 10, 1989 was predominantly southeast. A 25-degree directional change was observed for the measurements obtained on 11/9/89 at 6:00 p.m. The variation in direction could be caused by the major low tide event which occurred on 11/9/89 at 7:58 p.m. The 6:00 p.m. November 9 groundwater gradient direction is shown on Figure 2 by the arrow labeled number 4. This southeast direction of apparent groundwater flow is consistent with flow directions calculated with water level data collected on October 30, 1989, at the time of groundwater sampling.

A groundwater contour map utilizing groundwater level data collected on December 6, 1989 for the eight-monitoring-well network is presented in Figure 7. The groundwater contours or equipotential lines represent lines of equal hydraulic head. The direction of groundwater flow can be determined by drawing flow lines perpendicular to the contour lines. The December 6, 1989 data confirms previously calculated southeast groundwater flow directions at the site.

TABLE 1

STATIC WATER LEVEL ELEVATIONS

(feet)

Monitoring Well	11/9/89 11:30 am	11/9/89 6:00 pm	11/10/89 8:00 am	11/10/89 2:30 pm	12/6/89 12:00 pm
MW-2	8.86	8.83	8.84	8.98	9.60
MW-3(1)	8.34	8.36	8.25	8.49	9.12
MW-6	8.72	8.84	8.76	8.85	9.49
MW-11	8.60	8.60	8.45	8.79	9.46
MW-101	--	--	--	--	10.49
MW-102	--	--	--	--	8.81
MW-103	--	--	--	--	8.45
MW-104(1)	--	--	--	--	10.95

Note: (1) Static water level corrected for floating product

CHARACTERIZATION OF FLOATING HYDROCARBONS

Free product was measured in monitoring wells MW-104 and MW-3. Hydrocarbon thicknesses measured in these wells are listed in Table 2 with the approximate tide at the time of the measurement. A thin layer of hydrocarbons, 0.01 foot thick, was present in MW-104 while a significantly thicker layer, up to 0.69 foot, was measured in MW-3.

TABLE 2

FLOATING PRODUCT THICKNESS

Pacific Northern Oil, Terminal 91

Monitoring Well	Date	Time	Product Thickness (feet)	Approximate Tide (feet)
MW-3	10/30/89	1303	0.27	+8
MW-3	11/10/89	0806	0.69	+4
MW-3	11/09/89	1053	0.62	+9
MW-3	11/10/89	1255	0.49	+10
MW-3	11/09/89	1750	0.60	+5
MW-3	11/09/89	1333	0.50	+11
MW-104	12/06/89	1200	0.01	+12
MW-3	12/06/89	1210	0.24	+12

Tidal Influence

Product thickness in monitoring well MW-3 ranged from a maximum thickness of 0.69 foot at a +4-foot tide on November 10, 1989 to a minimum thickness of 0.24 foot at a +12-foot tide on December 6, 1989. Comparison of product thickness measurements made during November 9 and 10, 1989 suggests that an increase in product thickness accompanies a declining tide. For example, on November 10, 1989, the groundwater level in MW-3 rose 0.33 foot in response to a 6-foot tidal increase between 8:06 and 12:55 (Figure 5, Table 2). The thickness of petroleum hydrocarbons in this well declined by 0.20 foot during this time. Apparently, the rise of the water table lifts the free product, causing it to thin and spread over a larger area.

Lateral Extent

The two lenses of free product identified at Terminal 91 do not appear to be connected. The two wells with measurable floating product, MW-3 and MW-104, are separated by wells MW-2 and MW-6, which have not had a

measurable product thickness. Figure 8 shows the estimated extent of floating hydrocarbons in the vicinity of MW-3. The extent of floating product in the vicinity of MW-3 is constrained by the retaining wall and wells MW-1, MW-11, MW-6, and MW-2. The pipeline was excavated down to groundwater west of MW-6. A thin layer, approximately 0.01 foot, was measured in this excavation, indicating that the free product in this area extends as far west as the pipeline, but not as far west as MW-11 (Figure 8).

Additional wells are necessary to define the extent of the product lens at well MW-104. The discontinuous lenses of product may result from stratigraphic control on product migration, where the product migrates more readily through the sandy gravel unit where it occurs in well MW-3 (Figures 3 and 4). Alternatively, an unidentified retaining wall or other physical discontinuity may be present between MW-2 and MW-104 in the vicinity of the guard shack. A search of the Port of Seattle as-built diagrams stored on microfiche could be performed to explore this possibility. The possibility also exists that the two free product lenses result from two separate sources.

Product Recovery Test

On October 30, 1989, a product recovery test was performed on well MW-3. The purpose of the test was to estimate the rate of product inflow into the well to determine the feasibility of product extraction and to determine the true product thickness on the aquifer. Methodology and results of the bail test are presented in Appendix D. Results of the bail test indicate that the product will recover to approximately 75 percent of its initial thickness in one-half hour after bailing. Based on this recovery rate and a measured product thickness of a little over three inches, approximately 2 gallons of product/day could be obtained from this well.

The product thickness measured in wells is an apparent product thickness, which has been commonly accepted to be greater than the actual formation thickness. The apparent product thickness phenomenon is

attributed to the specific gravity of product and to capillary effects. Product accumulates on the capillary fringe, which is nearly saturated with water. The product will drain off the capillary fringe into the well casing, increasing product thickness and depressing the water level in the well. Appendix D presents the analysis of the bail test to determine the true product thickness. Analysis of the product bail test results indicate the true product thickness is less than a half-inch.

Volume Estimate

Estimates of the volume of floating hydrocarbons in the vicinity of well MW-3 were made based on product thicknesses estimated for high and low tide. In addition to hydrocarbon thickness, the variables in these analyses include porosity and areal extent of floating hydrocarbons.

The porosity of sand and gravel deposits typically range from 15 to 30 percent, with 20 percent as a typical value (Driscoll, 1986). The estimated areal extent of hydrocarbons as shown in Figure 8 is 7700 square feet. The areal extent of floating hydrocarbons is constrained by the absence of free product in monitoring wells MW-102 to the south, MW-11 to the west, MW-6 to the northeast and MW-2 to the north. In addition, a thin layer of hydrocarbons, 0.01 foot, was measured in an excavation around the pipeline between monitoring wells MW-3 and MW-11, indicating that some free product extends toward MW-11. The retaining wall, which the soils contaminant data indicates is a barrier to product migration, was used to constrain the extent of free product to the east. This area is approximately 11,450 square feet in extent.

Using a porosity of 20 percent and a true product thickness of 0.02 foot, as discussed in Appendix D, yields a free product thickness of approximately 340 gallons. Table 2 indicates that the free product thickness could be as much as three to four times greater during a low tide. Assuming a true product thickness four times greater at low tide and using the same areal extent and porosity, yields an estimated 1,370 gallons of free product in the vicinity of MW-3. These estimates are contingent on the estimate of the free product thickness obtained from the bail recovery test as well as other assumptions presented.

ANALYTICAL RESULTS

Soil Analyses

Soil samples were obtained at 2.5-foot sample intervals from borings MW-101 through MW-104. Three samples from each boring were selected for laboratory analyses of total petroleum hydrocarbons (TPH) using EPA method 418.1 based on field screening and depth to water table. Field screening and analytical results are presented in Table 3 with results of the GC/FID screen performed in the initial investigation by Hart Crowser. Laboratory reported analytical results and chain-of-custody records are presented in Appendix C.

TABLE 3
TOTAL PETROLEUM HYDROCARBON CONCENTRATIONS IN SOILS(1)
Pacific Northern Oil, Terminal 91

Boring Number	Sample Depth (feet)	HNU (ppm)	Petroleum Hydrocarbon Concentrations mg/kg (ppm)	Method	Comments
B-1	7.5	75	18000	GC/FID screen	diesel
	10	75	14000	GC/FID screen	diesel
	12.5	100	4300	GC/FID screen	diesel
	15	90	4200	GC/FID screen	diesel
	17.5	40	313	GC/FID screen	diesel
	20	9	<25	GC/FID screen	
MW-2	2.5	<1	NA		
	5	<1	NA		
	7.5	68	21000	GC/FID screen	diesel
	10	76	17000	GC/FID screen	diesel
	12.5	86	1900	GC/FID screen	diesel
	15	28	300	GC/FID screen	diesel
	17.5	24	140	GC/FID screen	bunker
MW-3	2.5	<1	230	GC/FID screen	diesel
	7.5	62	8000	GC/FID screen	diesel
	10	91	15000	GC/FID screen	diesel
	12.5	50	390	GC/FID screen	diesel
	15	70	490	GC/FID screen	diesel
	17.5	60	510	GC/FID screen	diesel

Table 3 (continued)

Boring Number	Sample Depth (feet)	HNU (ppm)	Petroleum Hydrocarbon Concentrations mg/kg (ppm)	Method	Comments
B-10	2.5	<1	<25	GC/FID screen	
	5	3	<25	GC/FID screen	
	7.5	1	NA		
	10	40	4900	GC/FID screen	diesel
	12.5	12	NA		
	15	11	NA		
	17.5	5	<25	GC/FID screen	
MW-11	2.5	<1	<25	GC/FID screen	
	5	<1	NA		
	7.5	2	79	GC/FID screen	unknown
	10	26	NA		
	12.5	24	1000	GC/FID screen	diesel
	15	14	NA		
	17.5	7	<25	GC/FID screen	
MW-101	7.5	10	4600	418.1	diesel
	10	4	310	418.1	diesel
	12.5	5	<20	418.1	diesel
MW-102	7.5	6	39000	418.1	diesel
	10	60	17000	418.1	diesel
	12.5	3	220	418.1	diesel
MW-103	7.5	1	4700	418.1	diesel
	10	3	7800	418.1	diesel
	12.5	3	47	418.1	diesel
MW-104	7.5	10	9000	418.1	diesel
	10	20	15000	418.1	diesel
	12.5	2	200	418.1	diesel

Note: (1) Analytical data for borings B-1 through B-11 including MW-2, MW-3, MW-6 and MW-11 from Hart Crowser, September 11, 1989

The majority of soil contamination occurs at the water table and the sample interval immediately above the water table. In general, petroleum hydrocarbon concentrations decline abruptly, immediately below the water table. A cleanup level of 200 parts per million (ppm) for total petroleum hydrocarbons in soil was established by the Washington State Department of Ecology (Ecology) for spills from petroleum storage tanks. With the exception of boring B-4, all soil samples taken at the water table (approximately 10 feet below ground surface, Table 3) exceed the 200 ppm cleanup level. Boring B-4 is located in the short fill area and is partitioned from the contaminated soil area by a retaining wall. The absence of TPH contamination at the water table on the east side of the retaining wall indicates the retaining wall probably acts as a barrier to petroleum migration. However, the product entering the lagoon appears to be seeping through or under the retaining wall.

Figures 9 and 10 are logarithmic contour plots of petroleum hydrocarbon concentrations above the water table (approximate elevation 10 feet MSL) and at the water table (approximate elevation 7.5 feet MSL). The diagrams were constructed based on GC/FID data from Hart Crowser and infrared spectroscopy (EPA method 418.1) data obtained in this investigation. Although comparison of these two data sets is somewhat tenuous, the figures indicate several trends in petroleum hydrocarbon concentration. The highest levels of petroleum hydrocarbon contamination occur along the east retaining wall where a maximum concentration of 39,000 mg/kg (ppm) was detected (Figures 9 and 10). Above the water table (Figure 9), petroleum hydrocarbon concentrations increase toward the northern portion of the east retaining wall. Furthermore, the TPH concentrations are generally greatest at the water table (Figure 10). The northeast increasing chemical gradient present immediately above the water table (Figure 9) becomes obscured at the elevation of the water table (Figure 10). These data indicate a source toward the northeast; however, the elevated TPH levels in MW-101 accompanied by the southeast groundwater flow direction suggests the possibility that more than one source may be contributing to the contamination.

Groundwater Analysis

Groundwater samples were collected on October 30, 1989 from wells MW-2, MW-3, MW-6, and MW-11 during the preliminary hydrogeologic assessment. A complete round of samples was collected from the four existing wells and the four new wells on December 6 and 7, 1989. Results of these sampling efforts are presented in Table 4. Laboratory reported analytical results and chain-of-custody forms are presented in Appendix C.

A cleanup goal of 15 ppm for total petroleum hydrocarbons in groundwater has been implemented by the Washington State Department of Ecology for spills from petroleum tanks. Monitoring well MW-3, which had a measurable floating product thickness of 0.27 foot, was the only well to exceed the Department of Ecology cleanup level during the October 30, 1989 sample event, with a TPH concentration of 730 mg/l (ppm). Monitoring well MW-2 had a TPH level of 15 ppm.

Monitoring wells MW-3 and MW-101 were the only wells to exceed Ecology's cleanup level in the December 6 and 7, 1989 sample event, with TPH concentrations of 54 and 28 mg/l (ppm), respectively (Table 4 and Figure 8). The TPH concentration in monitoring well MW-104, which had a 0.01 foot product layer prior to development, was 6.2 mg/l (ppm). Moreover, samples obtained on December 6 and 7, 1989 following well development, had significantly lower TPH values than samples obtained on October 30, 1989 prior to development. Additional monitoring is recommended to more fully characterize the TPH concentration in groundwater.

TABLE 4

TOTAL PETROLEUM HYDROCARBON CONCENTRATIONS IN GROUNDWATER

Pacific Northern Oil, Terminal 91

Monitoring Well	Date	Total Petroleum Hydrocarbons in mg/l (ppm)
MW-2	10/30/89	15
	12/07/89	3.0
MW-3	10/30/89	730
	12/07/89	52
MW-6	10/30/89	13
	12/06/89	2.8
MW-11	10/30/89	7.4
	12/07/89	<0.5
MW-101	12/07/89	28
MW-102	12/06/89	6.9
MW-103	12/06/89	6.9
MW-104	12/07/89	6.2

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Subsurface conditions consist of approximately 5 feet of sandy fill overlying relatively permeable native sands, gravelly sands, and sandy gravels.

2. Water level measurements indicate a predominantly southeasterly groundwater flow direction. A maximum change of 25 degrees in the groundwater flow direction occurred between high and low tides. The maximum groundwater fluctuation observed during one tide cycle was 0.34 foot.

3. Floating product was identified in monitoring wells MW-3 and MW-104. Product thickness in MW-3 ranged from 0.24 to 0.69 foot. The change in product thickness appears to be a function of tidal fluctuations where the free product layer increases with a declining tide. The areal extent of free product at MW-3 is constrained by monitoring wells MW-102 to the south, MW-11 to the west, MW-6 to the northwest and MW-2 to the north. The eastern extent is constrained by the east retaining wall. Using a porosity of 20 percent, a free product areal extent of 11,450 square feet, and a true product thickness range of 0.02 to 0.08 foot, an estimated 340 to 1,370 gallons of free product are present on site.

4. With the exception of the boring east of the east retaining wall, TPH contaminated soils were found throughout the area of investigation. Elevated levels of total petroleum hydrocarbons in soils occur predominantly at the water table and slightly above. Boring B-4, installed in an earlier investigation, had TPH concentrations below the detection limit at the water table indicating the retaining wall serves as a barrier to product migration, although product entering the short fill lagoon appears to be migrating through or under this wall. The TPH concentrations in soils generally increase from west to east with the highest concentrations along the north end of the east retaining wall.

5. Monitoring wells exceeding the Department of Ecology cleanup guidelines of 15 ppm for groundwater include wells MW-3 and MW-101. Monitoring well MW-2 had a TPH level equal to the cleanup guideline during the October 30, 1989 sample event. Monitoring well MW-104, which had a 0.01 foot layer of free product prior to well development, had a TPH concentration of 6.2 mg/l (ppm). TPH concentrations were significantly lower in samples obtained after well development.

6. The product recovery test indicates a relatively slow rate of product recovery in MW-3. Using the existing 2-inch diameter monitoring well for product extraction, approximately 2 gallons/day of product could be obtained. This yield could be increased by a larger diameter well or sump.

Recommendations

1. Additional excavation along the pipeline could be used to locate unknown branches of the pipeline, which may be a potential source. If additional excavation is not planned, ground penetrating radar could be used to located any unknown underground pipes.

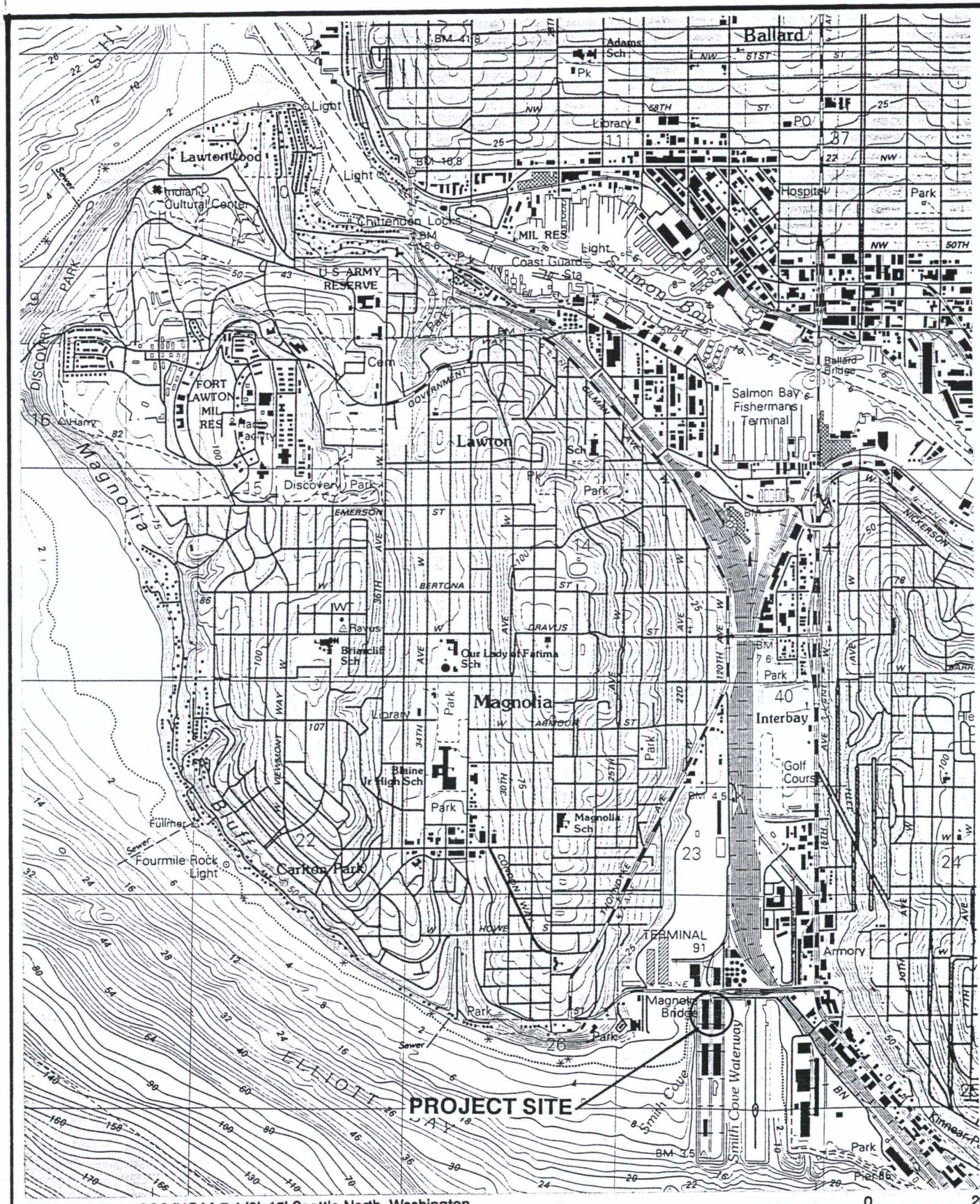
2. A large-diameter recovery well or sump in conjunction with a product recovery system is recommended in the vicinity of MW-3 for extraction of floating hydrocarbons in this area. This system would be used for interim product removal and could be expanded at a later date pending further definition of the contamination extent.

3. Once the product recovery system is in place, a pump test is recommended to determine the continuity of the aquifer and the connection between monitoring wells and product lenses.

4. Obtain chemical and groundwater level data from the Port of Seattle for their investigation of a leaking underground storage tank located at the north end of the cold storage warehouse.

5. Resample the eight existing monitoring wells to more adequately characterize the TPH levels in groundwater.

6. Based on the results of recommendations 3, 4 and 5 above, site additional monitoring wells, if appropriate.



REFERENCE: USGS/NOAA 7-1/2'x15' Seattle North, Washington.

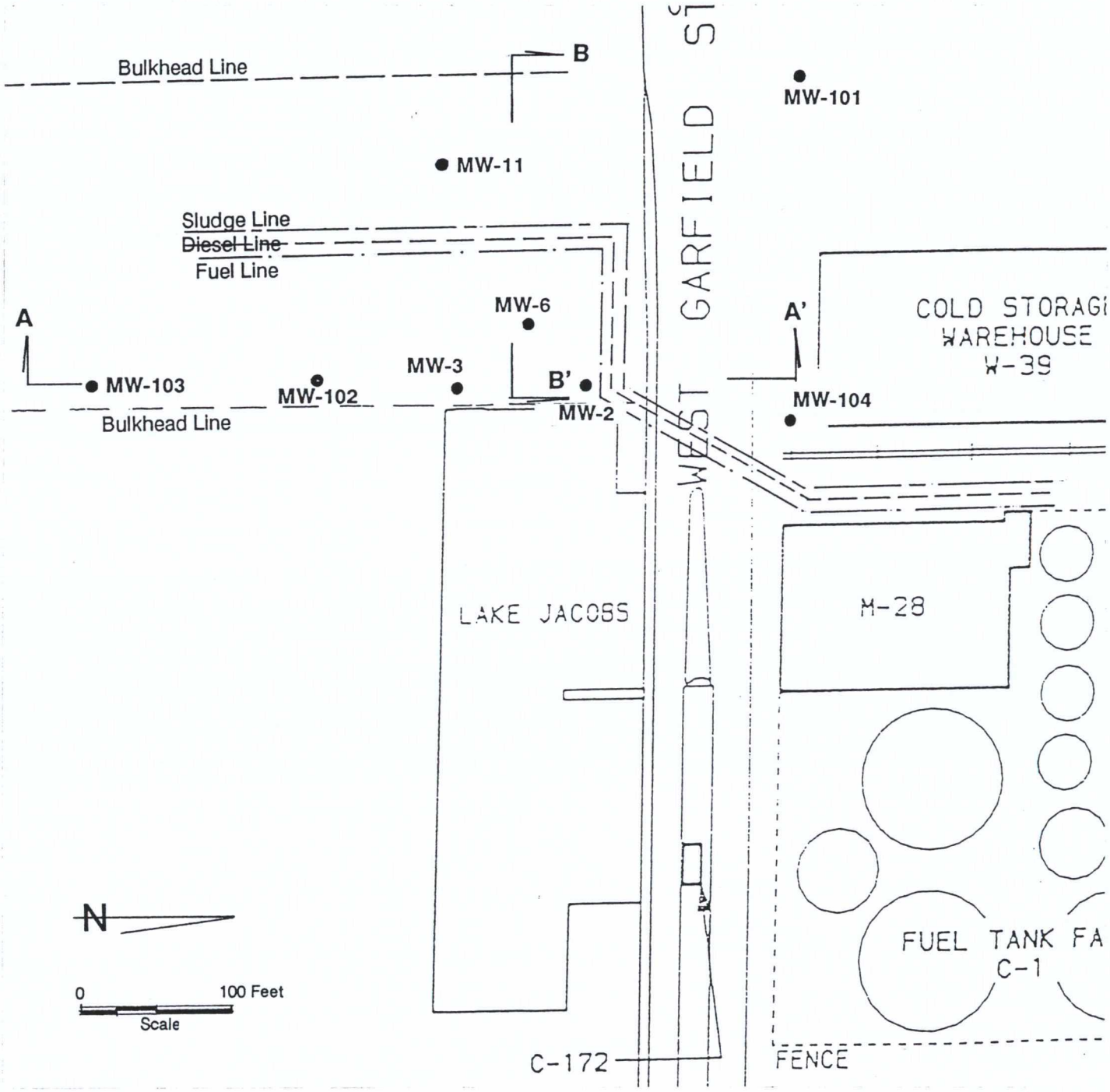
0 2000 Feet

Approximate Scale

Figure No. 1
PROJECT LOCATION MAP
Pacific Northern Oil - Terminal 91

89-45527-01

Converse GES



LEGEND:

MW-3 ● Monitoring well

Location of cross section

Figure No. 2
MONITORING WELL LOCATION MAP
Pacific Northern Oil - Terminal 91

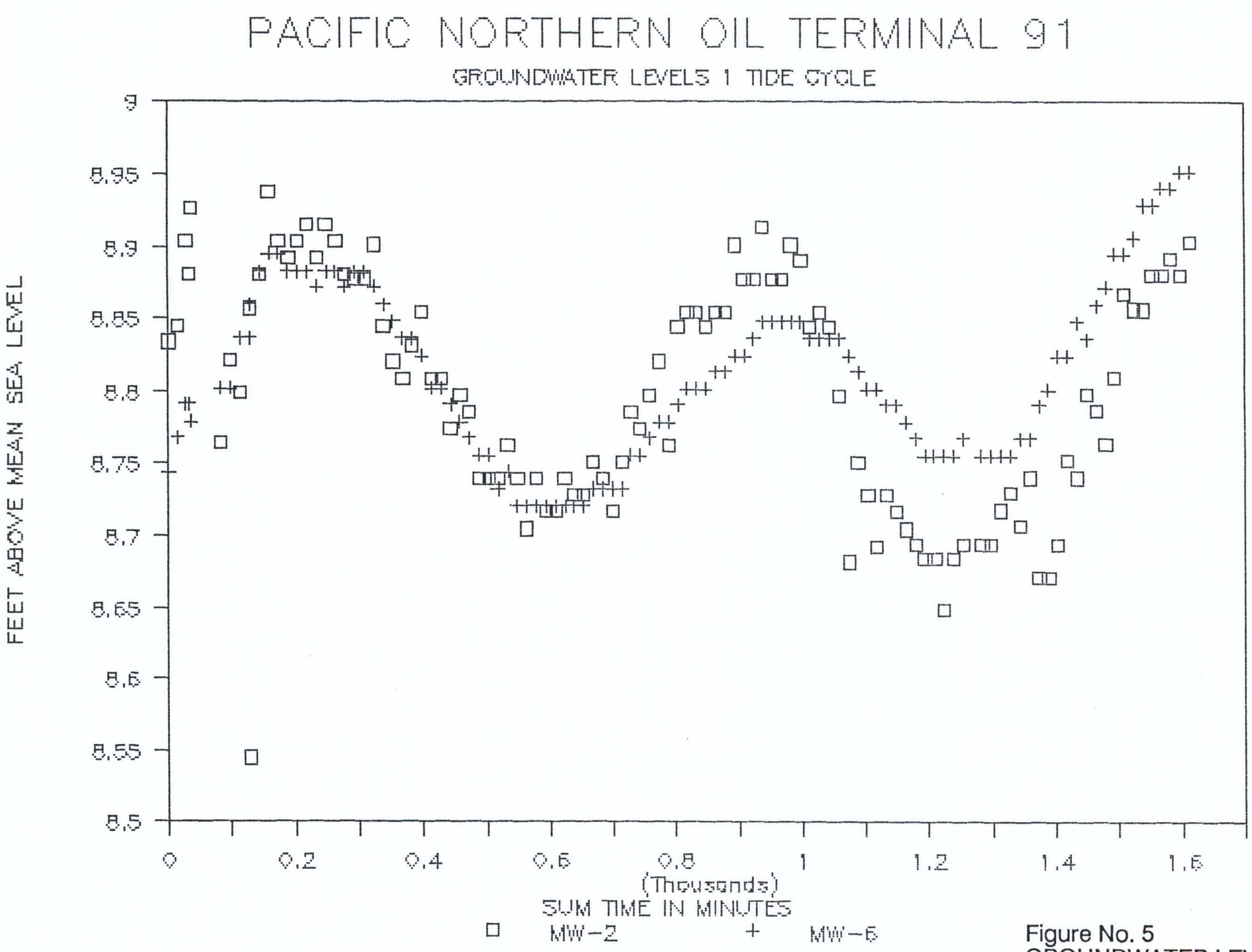
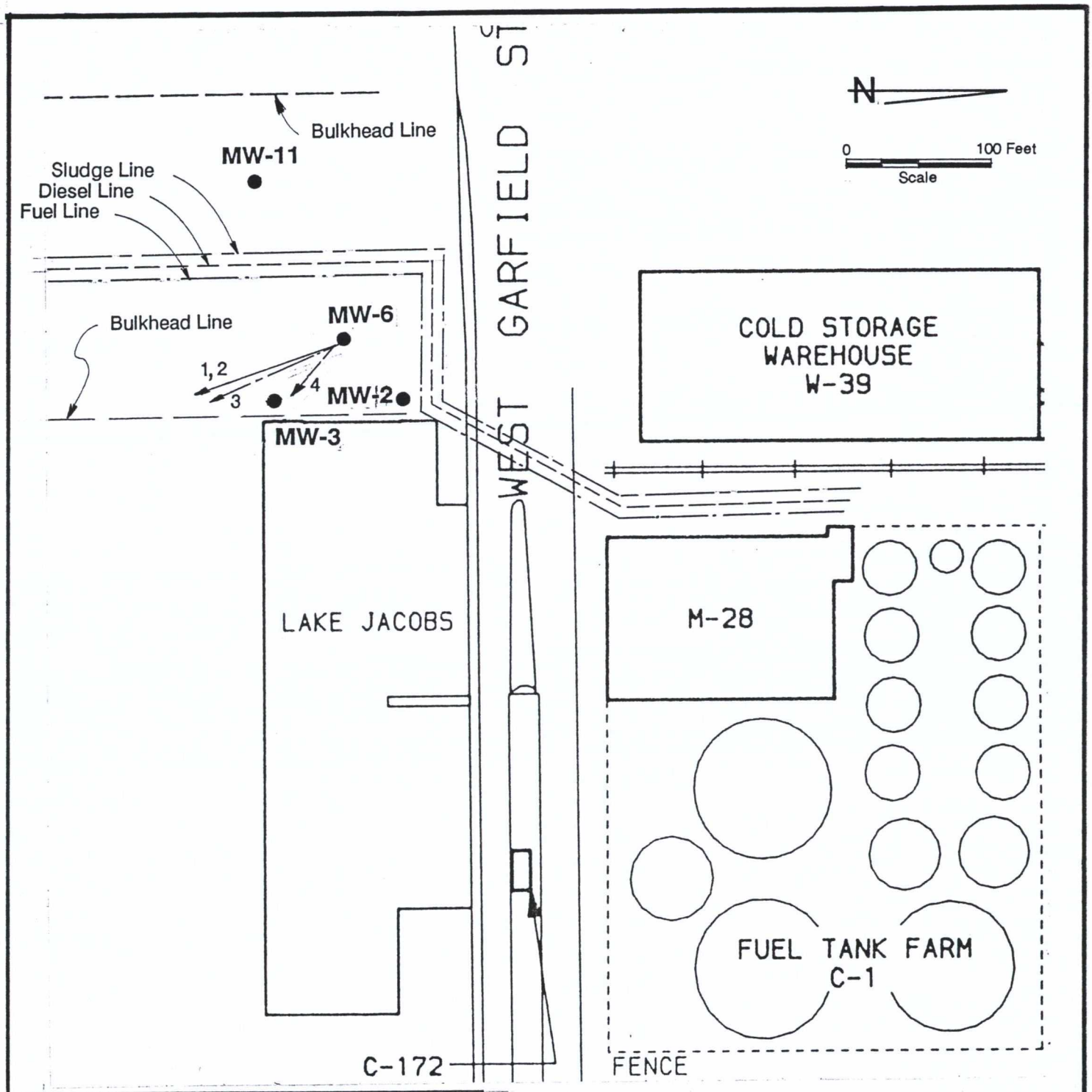
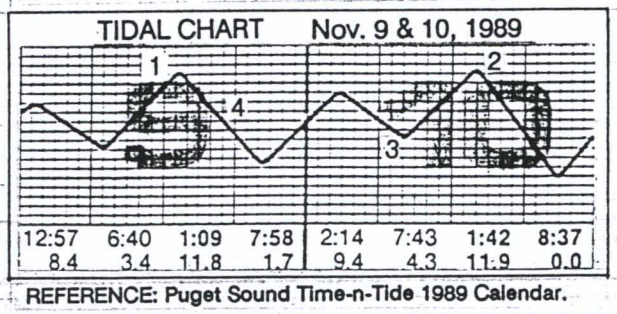


Figure No. 5
GROUNDWATER LEVELS - 1 TIDE CYCLE
Pacific Northern Oil - Terminal 91

89-45527-01





REFERENCE: Puget Sound Time-n-Tide 1989 Calendar.

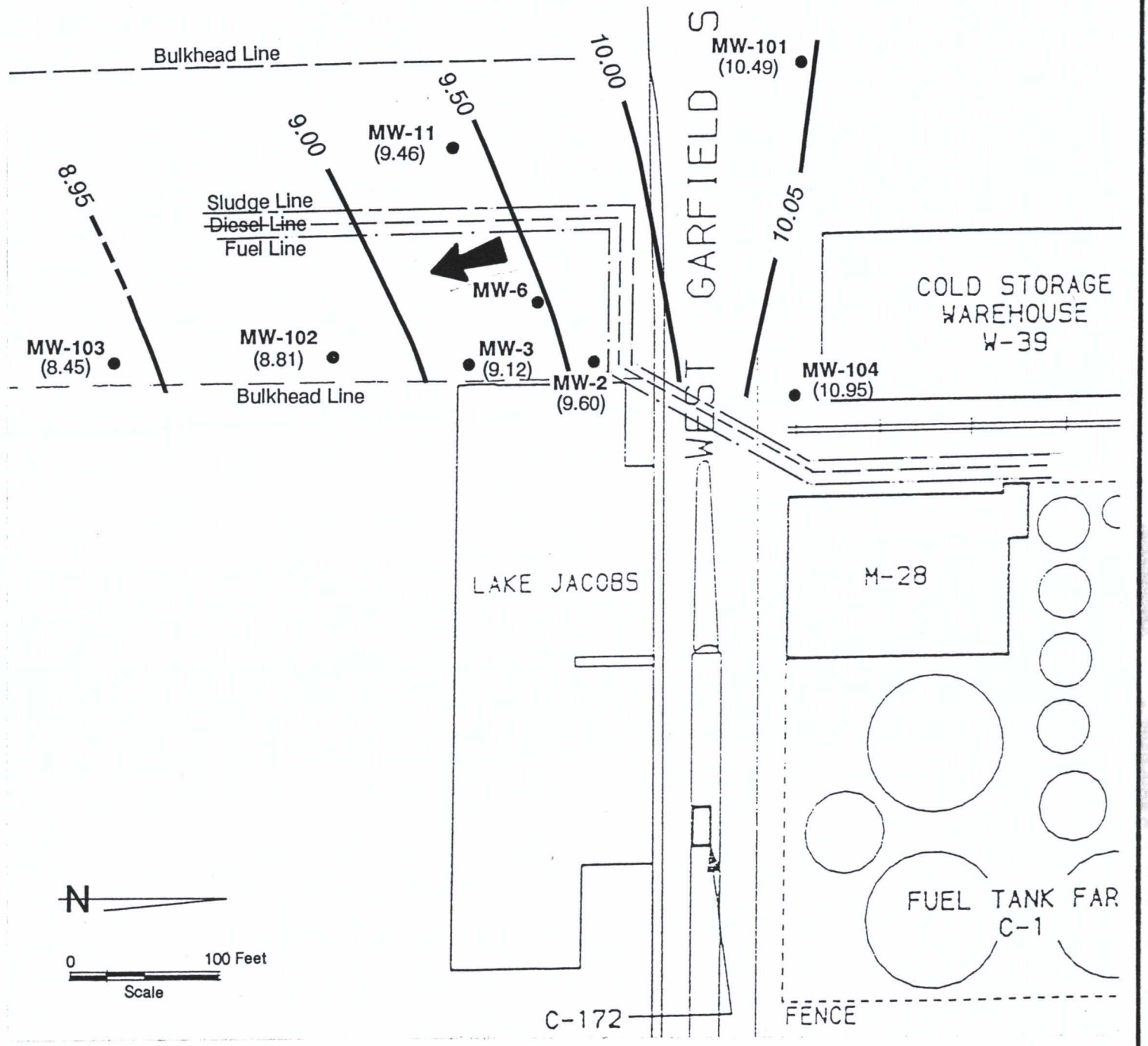
LEGEND:

MW-6 ● Groundwater monitoring well

Groundwater gradient

1 Nov. 9 11:30 a.m. high tide
2 Nov. 10 2:30 p.m. high tide
3 Nov. 10 8:00 a.m. low tide
4 Nov. 9 6:00 p.m. low tide

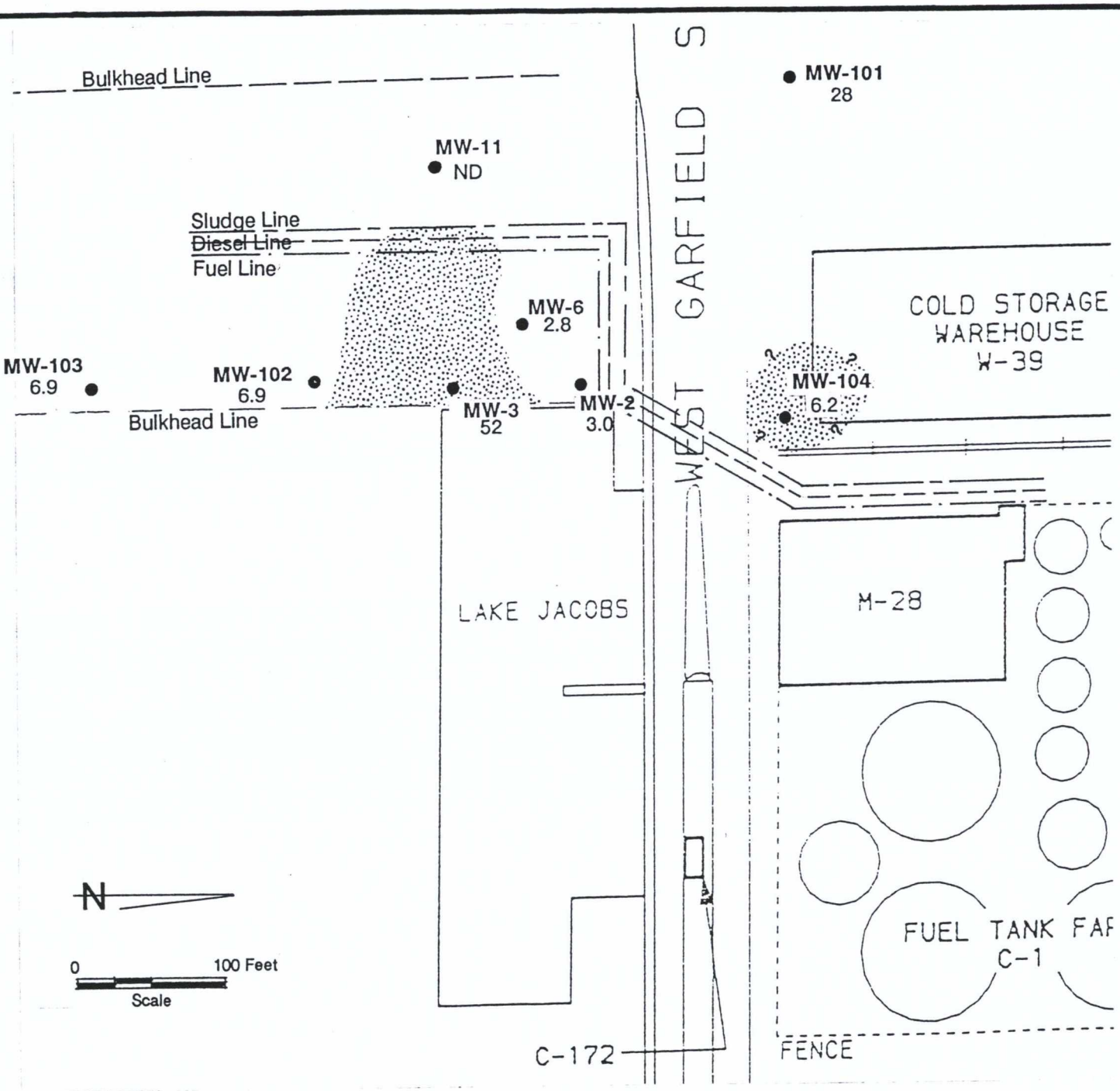
Figure No. 6
GROUNDWATER FLOW DIRECTION - 1 TIDE CYCLE
Pacific Northern Oil - Terminal 91



LEGEND:

MW-2 ● (10.49) Monitoring well (groundwater elevation)

Figure No. 7
GROUNDWATER LEVELS - DEC. 1989
Pacific Northern Oil - Terminal 91



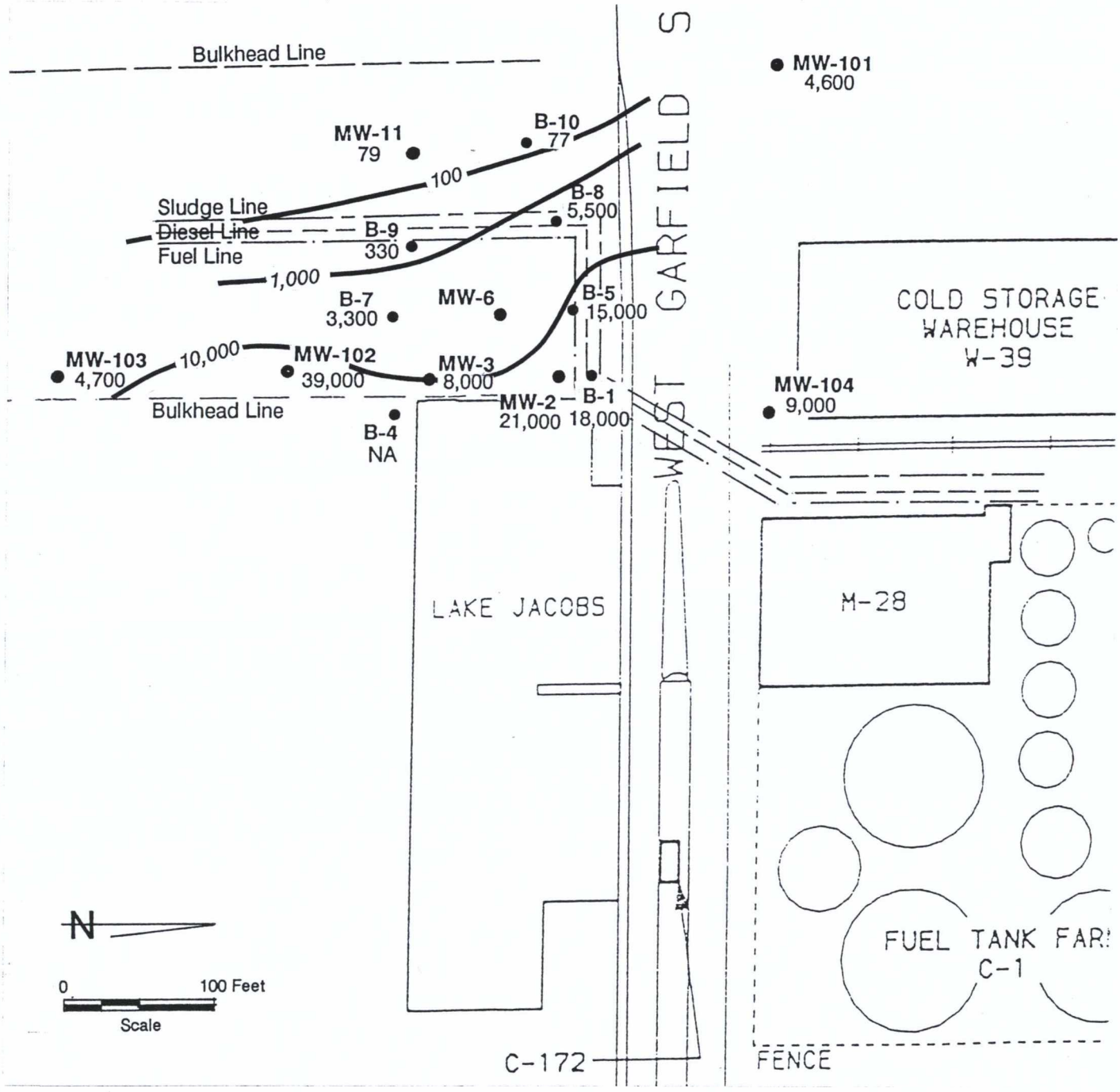
LEGEND:

MW-3 ● Monitoring well

52 TPH in groundwater in mg/l (ppm) sampled Dec. 6, 7, 1989 ND - Not detected

Estimated extent of floating hydrocarbons in vicinity of MW-3

Figure No. 8
ESTIMATED EXTENT OF FLOATING HYDROCARBONS IN VICINITY OF MW-3 AND TPH VALUES IN GROUNDWATER
Pacific Northern Oil - Terminal 91



LEGEND:

MW-101 ● — Monitoring well

B-7 ● — Soil boring

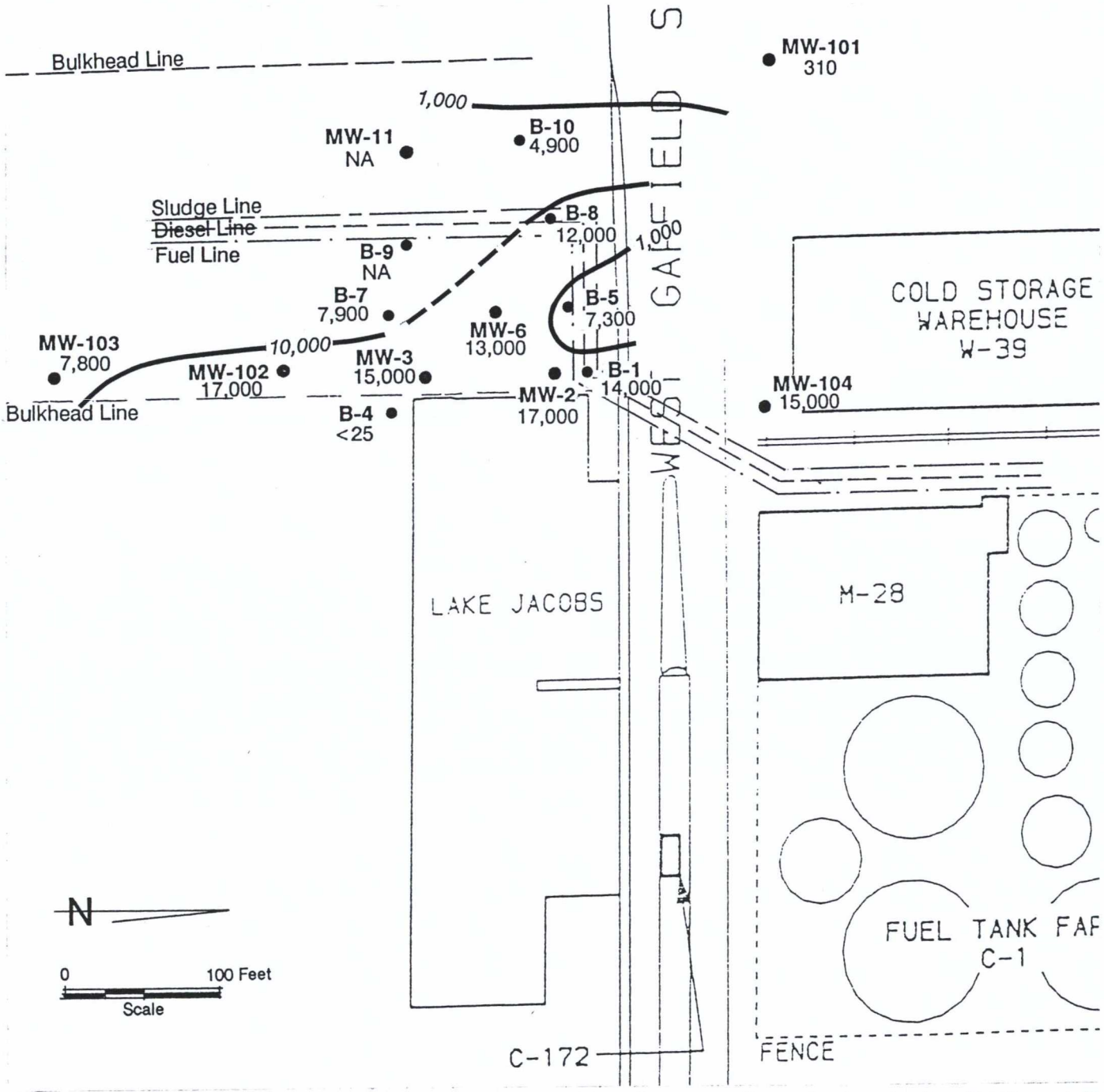
3,300 — Petroleum hydrocarbon concentration in mg/kg

NA - Not analyzed

100 — Logarithmic contour of Petroleum Hydrocarbon concentration in mg/kg (ppm)

(1) Analyses on soil samples from borings B-1 through B-11 and monitoring wells MW-2, MW-3, MW-6, and MW-11 were performed by Hart Crowser using GC/FID Method. Soil samples from MW-101 through MW-104 were analyzed using EPA Method 418.1.

Figure No. 9
LOGARITHMIC CONTOUR DIAGRAM OF PETROLEUM HYDROCARBON CONTAMINATION IN SOILS SAMPLES AT 10 FEET MSL(1)
Pacific Northern Oil - Terminal 91



LEGEND:

MW-11 ● Monitoring well

B-7 ● Soil boring

7,900 Petroleum hydrocarbon concentration in mg/kg

1,000 Logarithmic contour of Petroleum Hydrocarbon concentration in mg/kg (ppm)

(1) Analyses on soil samples from borings B-1 through B-11 and monitoring wells MW-2, MW-3, MW-6, and MW-11 were performed by Hart Crowser using GC/FID Method. Soil samples from MW-101 through MW-104 were analyzed using EPA Method 418.1.

Figure No. 10
LOGARITHMIC CONTOUR DIAGRAM OF PETROLEUM HYDROCARBON CONTAMINATION IN SOILS SAMPLES AT 7.5 FEET MSL(1)
Pacific Northern Oil - Terminal 91

Appendix A

APPENDIX A

DRILLING AND MONITORING WELL INSTALLATIONS

Drilling and Soil Sampling

Four borings were drilled and completed as groundwater monitoring wells at the Pacific Northern Oil Terminal 91 site using a truck mounted hollow-stem auger drill rig on November 29 and 30, 1989. Ten-inch outside diameter hollow-stem augers were utilized for drilling. Borings were advanced to a nominal depth of 17 feet. The monitoring well borings were logged by a geologist from Converse and soils were visually classified according to the ASTM D-2488-84 method. The boring logs for the newly installed groundwater monitoring wells are presented in Figures A-1 through A-4 and the boring logs from the previous investigation by Hart Crowser are included following Figure A-4.

Port of Seattle engineering drawings were carefully reviewed prior to drilling to determine the location of buried utility lines. In addition, the underground extension of utilities identified in the field were traced using a Goldak pipe-cable locator.

Soil samples were obtained at 2.5-foot intervals using a 2-inch outside diameter split-spoon sampler during hollow-stem auger drilling. The sampler was driven 18 inches with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler 6 inches is recorded on the boring logs. The soil from the split spoon was removed with a stainless steel spatula and placed in an 8-ounce glass jar, capped, and labeled. The samples were then placed in an ice chest cooled with blue ice and hand carried under chain-of-custody control to Laucks Testing Laboratories in Seattle. A portion of each sample was placed in a ziplock bag and field screened for organic vapors using an HNU systems photoionization trace gas detector. The HNU has a detection limit of 0.1 ppm total organic vapors with a range from 0.1 to 2000 ppm. Selected soil samples based on HNU screening and proximity to the water

table were sent to Laucks Testing Laboratories for chemical analysis of total petroleum hydrocarbons using EPA method 418.1. The samples analyzed in the laboratory are denoted on the boring logs by the symbol "C".

All downhole drilling equipment was steam-cleaned prior to initiation of drilling each hole to minimize the potential for cross contamination. Split spoon samplers were decontaminated between each sample interval utilizing a Liquinox wash, a potable water rinse, methanol rinse and finally a distilled water rinse.

Monitoring Well Installation

The location of the monitoring wells are shown on Figure 2. The wells labeled MW-101, MW-102, MW-103 and MW-104 were installed as part of the Phase I Remedial Investigation. All boring locations were selected based on the results of the site hydrogeology and existing contaminant data derived during the preliminary hydrogeologic assessment (Converse GES, November 22, 1989)

Monitoring wells consisted of 4-inch diameter flush-threaded, schedule 40 PVC with threaded joints and 10 feet of machine slotted PVC screen with 0.01-inch slot size. The annular space between the screen and wall of the boring was backfilled with sieve size #16 x #30 Colorado silica sand to act as a filter pack. The sand pack extends from the bottom of the hole to a distance of 2 feet above the screened interval. The annular space immediately above the filter pack was sealed with 2 feet of bentonite chips to prevent migration of contaminants down the annular space of the boring. The remaining annular space above the concrete grout was backfilled with cement grout. The well heads were protected with a flush-mount monument at the ground surface.

Converse GES

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
89-45527	MW-101	1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.55
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Start Date: November 29, 1989
Drilling Contractor: GeoBoring Develop.
Finish Date: November 29, 1989
Drilling Method: HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/ 6"	Hnu Test	Description
	locking, water tight, flush metal monument			14 7 7		Asphalt 2-inches SAND WITH GRAVEL (Fill); brown, medium; medium dense, dry
	concrete grout annular seal				0 ppm	
2						SAND (Fill); brown, little gray pea gravel; dense, dry
				3 14 24	0 ppm	
	blank well casing 4" ID PVC schedule 40					
4	bentonite seal					GRAVEL (Fill); medium to coarse; very dense, moist - encountered hard flat surface, drilled to refusal - boring moved 4 feet south and restarted
				19 18 10	17 ppm	SAND; gray, coarse; medium dense, moist
6						
	12/6/89					
		C		7 8 10	10 ppm	SANDY GRAVEL; gray, coarse sand matrix, trace shell fragments; medium dense, wet (strong petroleum odor)
8	ATD					
	well screen, 4"ID PVC schedule 40, .010 slot width					
10		C		1 1 2	4 ppm	SAND; gray; coarse; loose, wet (strong petroleum odor and sheen)
12	filter pack 16/30 Colorado silica sand					
		C		4 5 7	5 ppm	SANDY GRAVEL; gray, coarse sand matrix, trace shell fragments; medium dense, wet (strong petroleum odor and sheen)
14						
				5 9 12	3 ppm	
16						Total depth of boring at 16.3 feet.
18						

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: JJS
Approved by: EWM

Figure No. A-1

Converse GES

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
89-45527	MW-102	1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.5
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Start Date: November 30, 1989
Drilling Contractor: GeoBoring Develop.
Finish Date: November 30, 1989
Drilling Method: HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/ 6"	Hnu Test	Description
	locking , water tight, flush metal monument			24 38 62		Asphalt 2-inches SAND (Fill); gray brown, little pea-gravel; very dense, moist
	concrete grout annular seal					
2						-no sample recovery driving on pea-gravel
	blank well casing 4"ID PVC schedule 40			4 6 3		
4						
	bentonite seal			7 15 11	0 ppm	SAND; gray, little gravel, with stringers of fine sandy silt; medium dense, very moist
6						
		C		5 4 2	6 ppm	SANDY GRAVEL; gray, fine to medium sand matrix; loose, wet
8	ATD 12/6/89					
	well screen 4" ID PVC schedule 40,.010 slot width	C		2 3 2	60 ppm	SAND; dark gray, coarse, trace shell fragments; loose, wet (strong petroleum odor)
10						
12		C		3 5 6	3 ppm	SAND; dark gray, medium sand, grading into coarse gray sand, trace shell fragments; medium dense, wet (strong petroleum odor)
14	filter pack 16/30 Colorado silica sand					
				4 6 7	1 ppm	- sand grades with 1/8-inch stringers of gray clay, thinly bedded with gray sand, trace shell fragments; medium dense, wet
16						
18						Total depth of boring 17 feet.

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: JJS
Approved by: EWM

Figure No. A-2

Converse GES

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
89-45527	MW-103	1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.43
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Start Date: November 29, 1989
Drilling Contractor: GeoBoring Develop.
Finish Date: November 29, 1989
Drilling Method: HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/ 6"	Hnu Test	Description
	locking, water tight, flush metal monument			17 23		Asphalt 2-inches SAND (Fill); brown, medium, trace pea-gravel; very dense, dry
	concrete annular seal					SAND (Fill); brown, fine thinly bedded with gray coarse sand; medium dense, moist
2				7 10 12	0 ppm	
	blank well casing 4" ID PVC schedule 40					
4	bentonite seal					
				8 5 10	0 ppm	SAND; gray to iron stained; fine to medium; medium dense, moist
6						
	well screen, 4"ID PVC schedule 40,.010 slot width	C		8 14 13	1 ppm	SAND; gray, coarse, trace gravel; medium dense, moist (petroleum odor)
8	12/6/89					
10	ATD	C		7 9 11	3 ppm	SANDY GRAVEL; gray, coarse sand matrix; wet (petroleum odor)
12		C		3 2 3		SAND; gray, coarse, thinly bedded with silty sand, trace shell fragments; loose, wet
14	filter pack 16/30 Colorado silica sand					
				2 6 10	1 ppm	-grades with less shell fragments (petroleum sheen)
16						
18						Total depth 17 feet.

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: JJS
Approved by: EWM

Figure No. A-3

Converse GES

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
89-45527	MW-104	1 of 1

Project: Phase I Remedial Investigation
Location: Pier 91 Seattle, Washington
Elevation (Approx. Top of Well Casing): 17.46
Surface Elevation (Approx.):
Water Level Elev. (Approx.):
Start Date: November 30, 1989
Drilling Contractor: GeoBoring Develop.
Finish Date: November 30, 1989
Drilling Method: HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	Hnu Test	Description
	locking, water tight, flush metal monument concrete grout annular seal			13 11 13		Asphalt 2-inches SAND (Fill); brown, medium sand, little gravel; medium dense, dry
					0 ppm	
2						SAND; tan, coarse, trace shell fragments; medium dense, dry
				3 5 7	0 ppm	
	bentonite seal					
4						
	blank well casing 4" ID PVC schedule 40			2 3 3	0 ppm	grades to thinly bedded with gray coarse sand, trace shell fragments; loose, very moist
6						
	12/6/89					
						SANDY GRAVEL; gray, coarse sand matrix; medium dense, wet
		C		6 9 12	10 ppm	
8						
	ATD					
	well screen, 4" ID PVC schedule 40, .010 slot width					
10		C		5 9 8	20 ppm	- grades with strong petroleum odor
						-grades with slight petroleum odor
12	filter pack 16/30 Colorado silica sand	C		4 9 8	2 ppm	
14						
				2 3 5	2 ppm	SANDY GRAVEL; dark gray, thinly bedded with coarse sand; medium dense, wet (petroleum sheen on soils)
16						
18						Total depth 17.4 feet.

ST - Sampler Type:
- 4" I.D. Split Spoon
- Bulk Grab Sample
- Drive Barrel

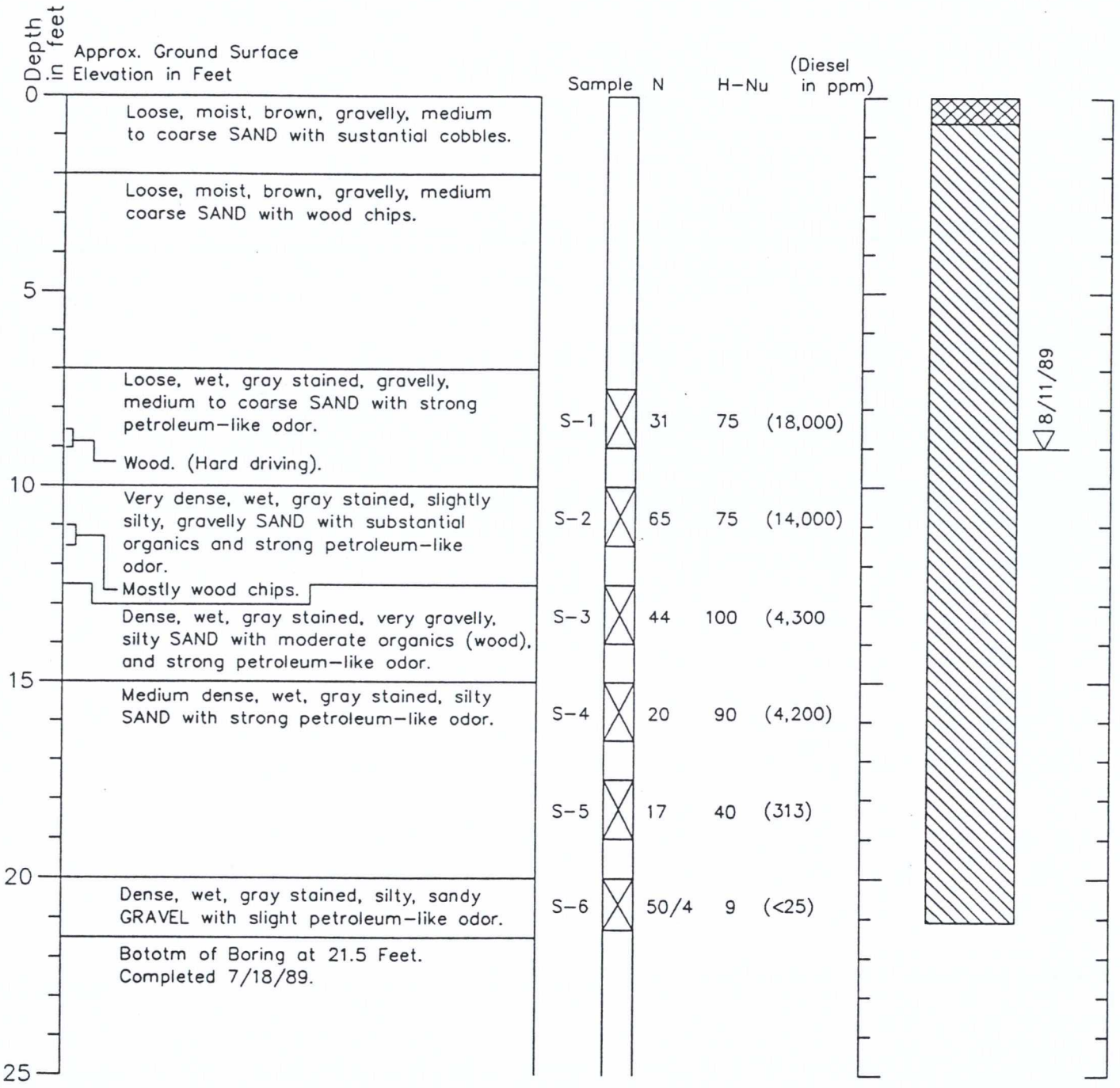
Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: JJS
Approved by: EWM

Figure No. A-4

Boring Log B-1

Geologic Log



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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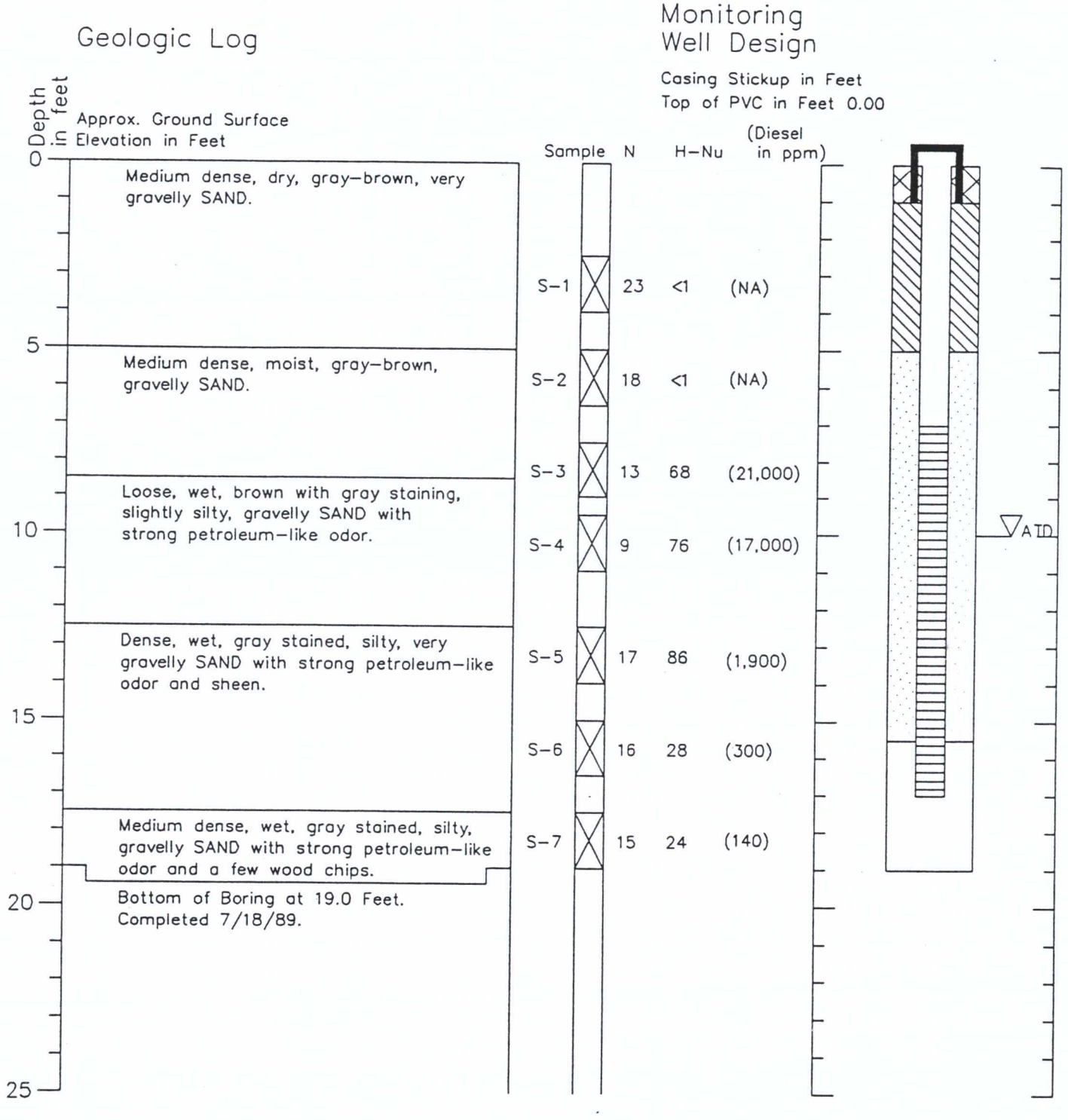
J-2500 7/89

Figure 3

Boring Log and Construction Data for Monitoring Well B-2



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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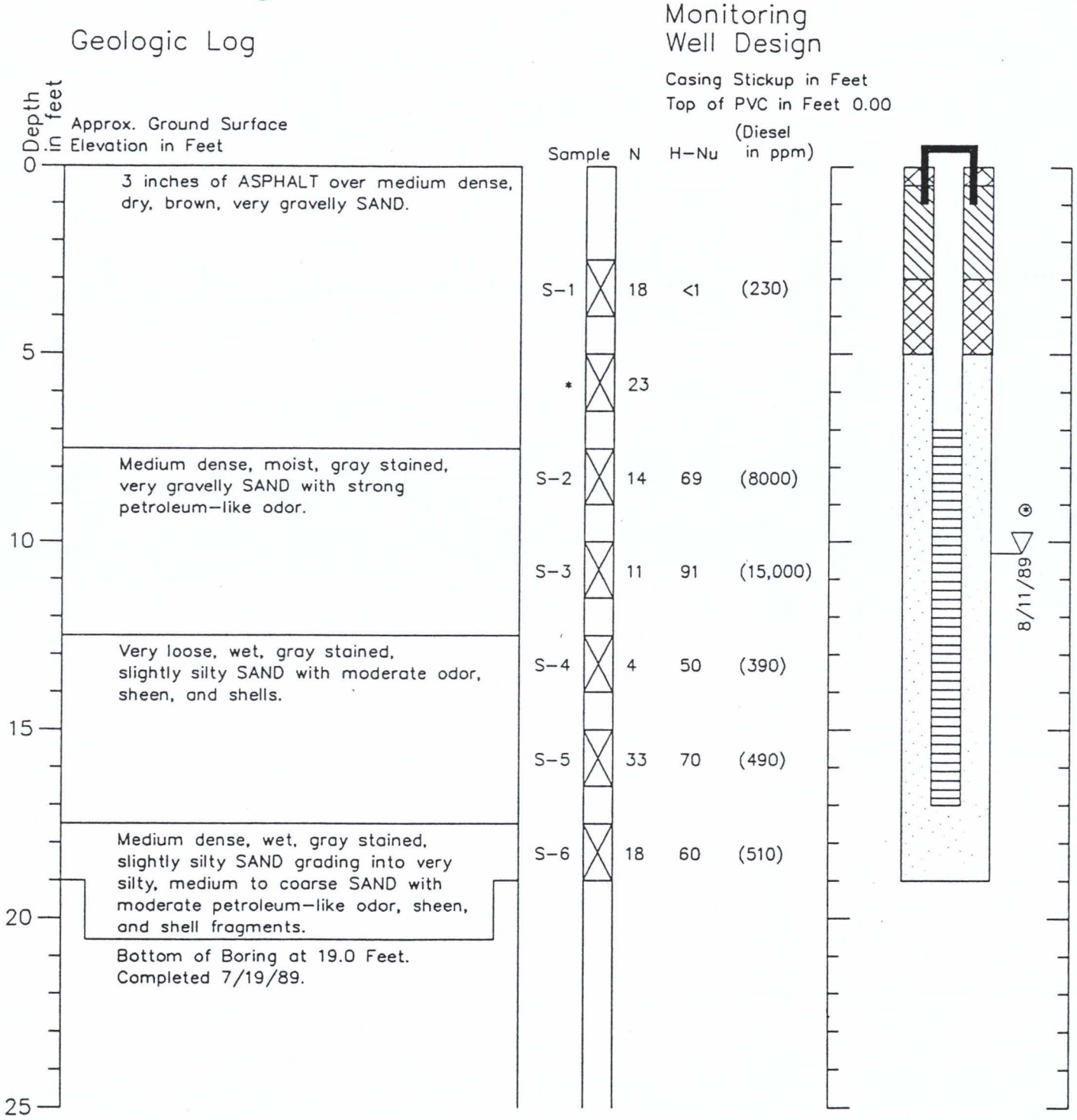
Figure 4

Boring Log and Construction Data for Monitoring Well B-3



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

⊛ Depth to free product at 9.4 feet.

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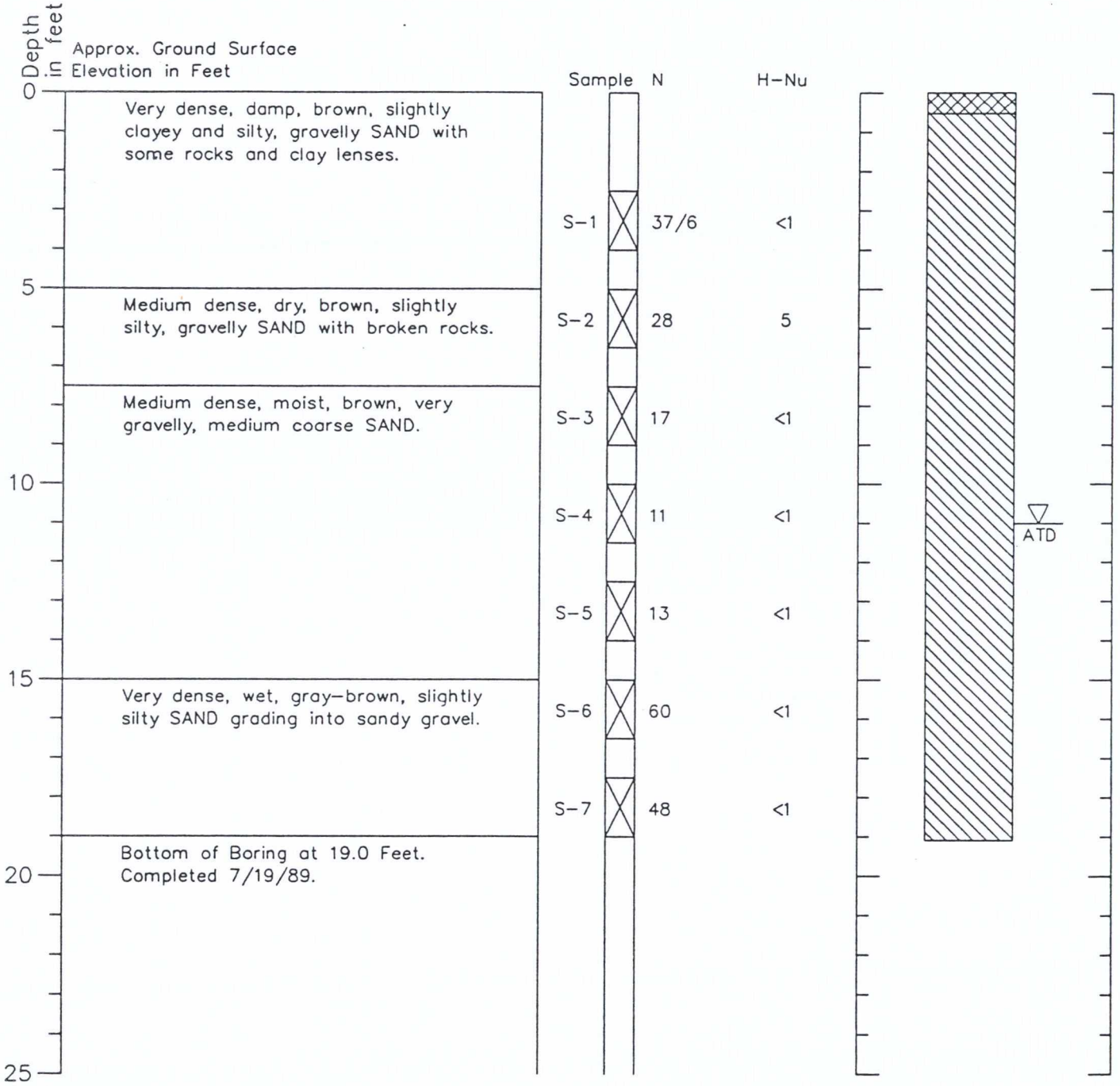
Figure 5

Boring Log B-4

Geologic Log



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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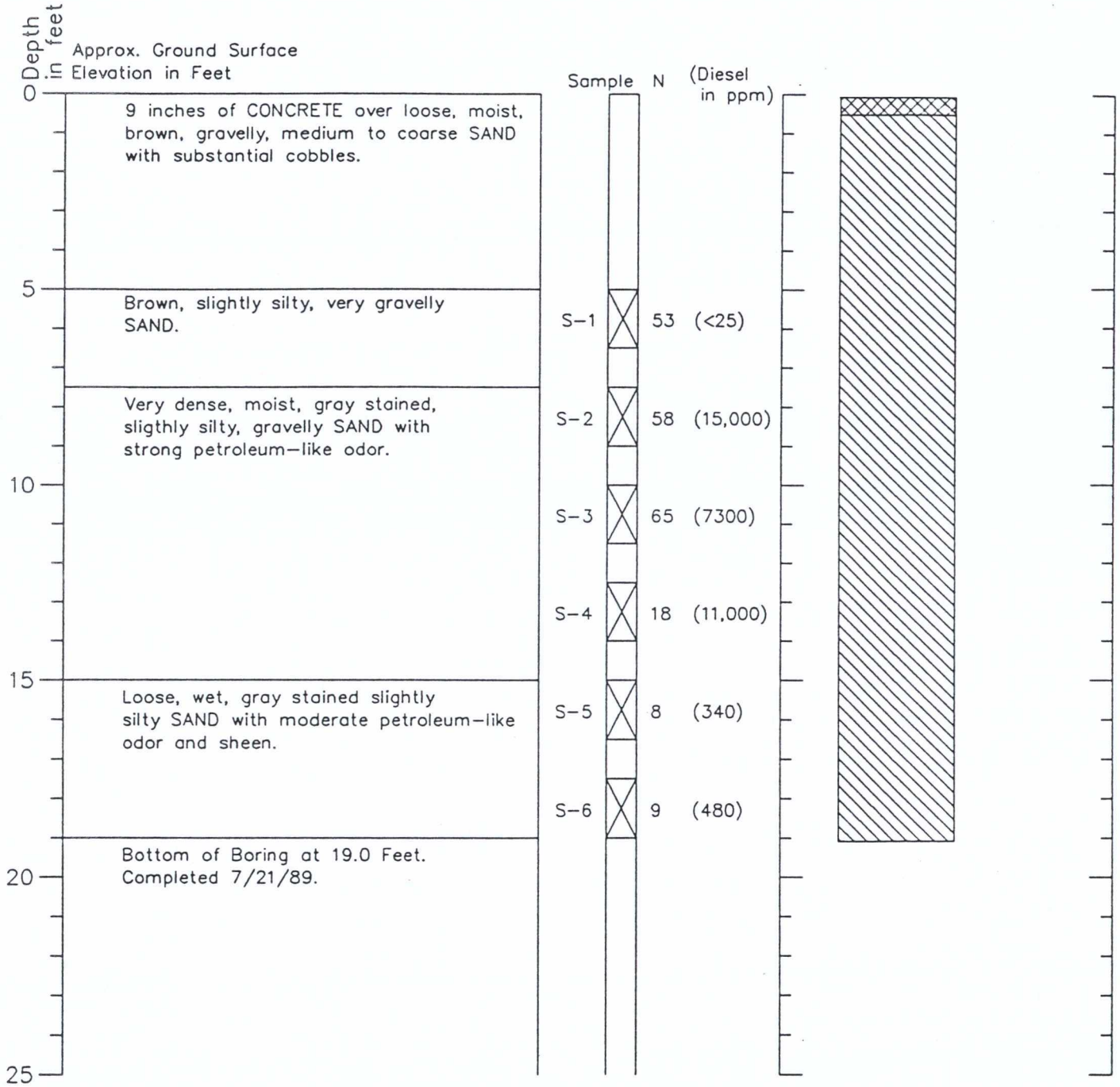
Figure 6

Boring Log B-5

Geologic Log



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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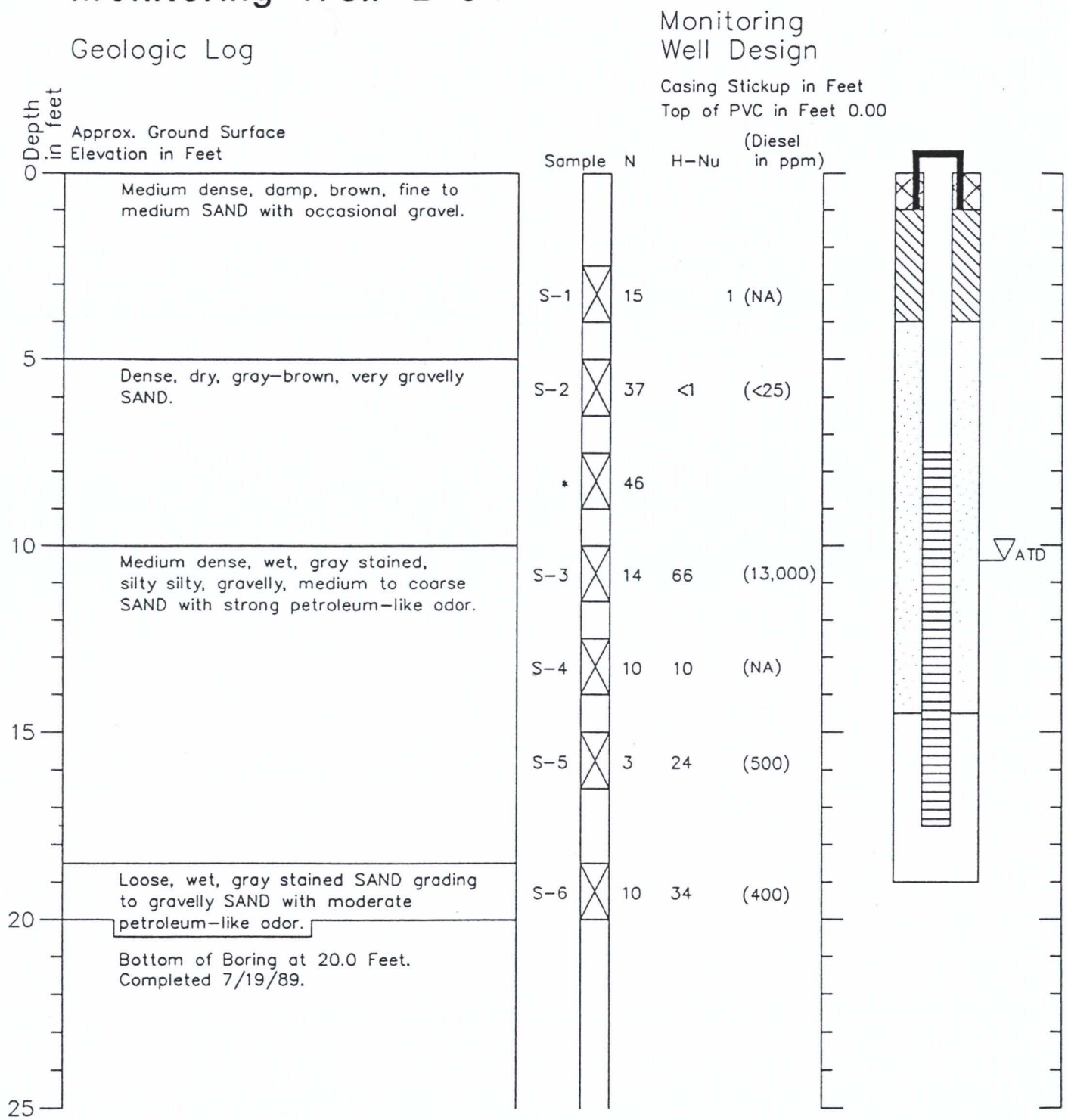
Figure 7

Boring Log and Construction Data for Monitoring Well B-6



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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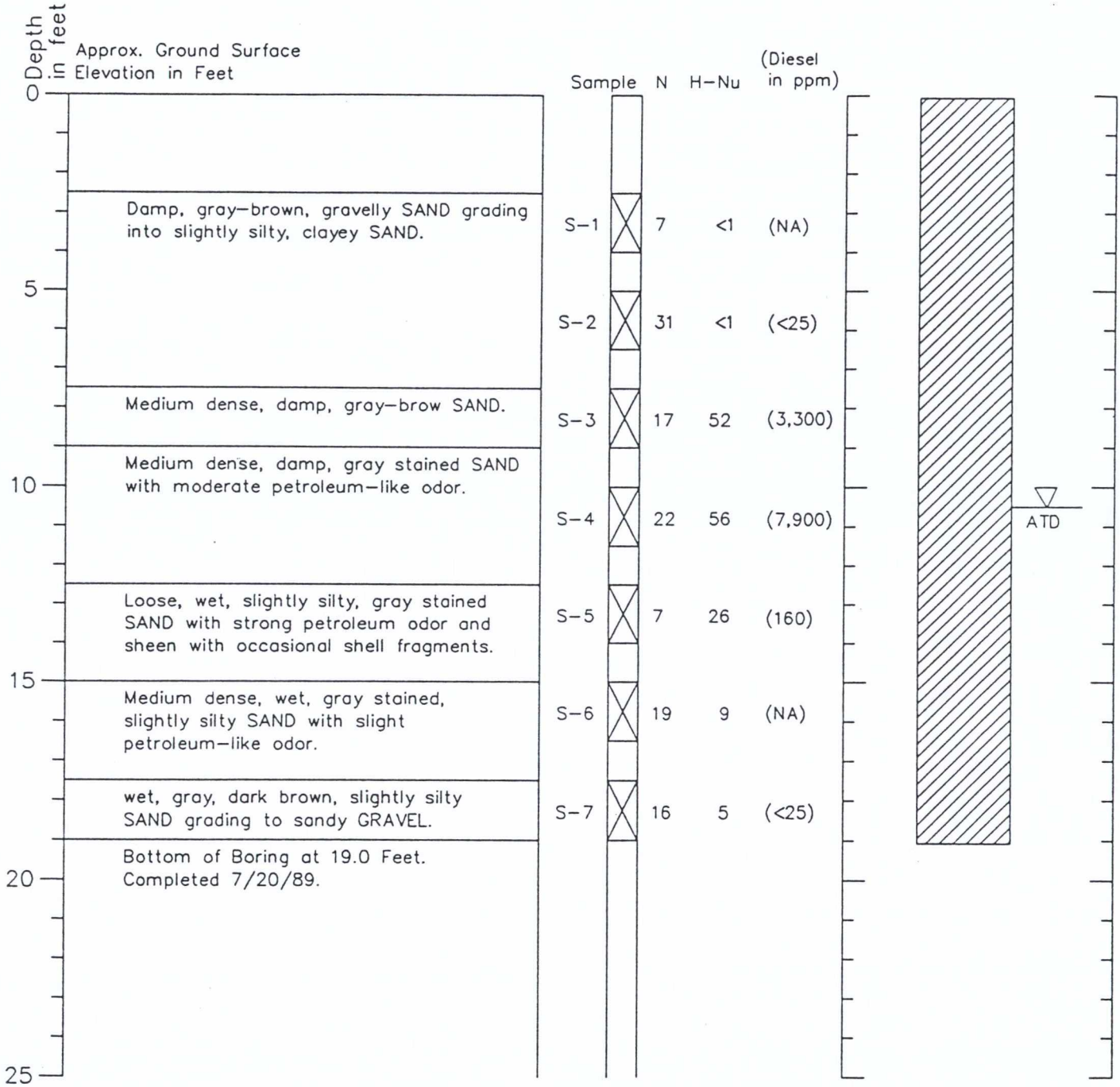
Figure 8

Boring Log B-7

Geologic Log



1. Refer to Figure 2 for explanation on descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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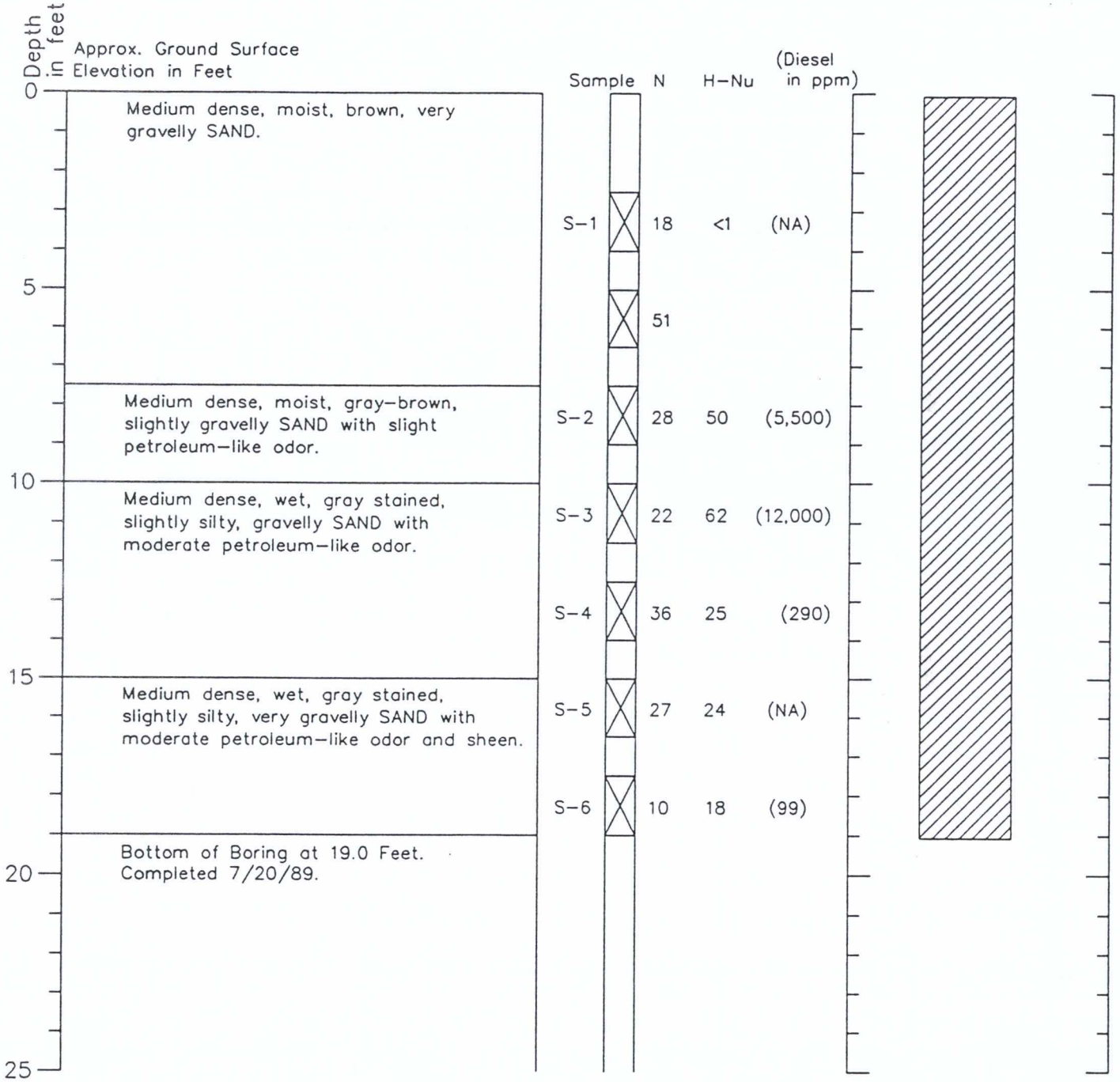
Figure 9

Boring Log B-8

Geologic Log



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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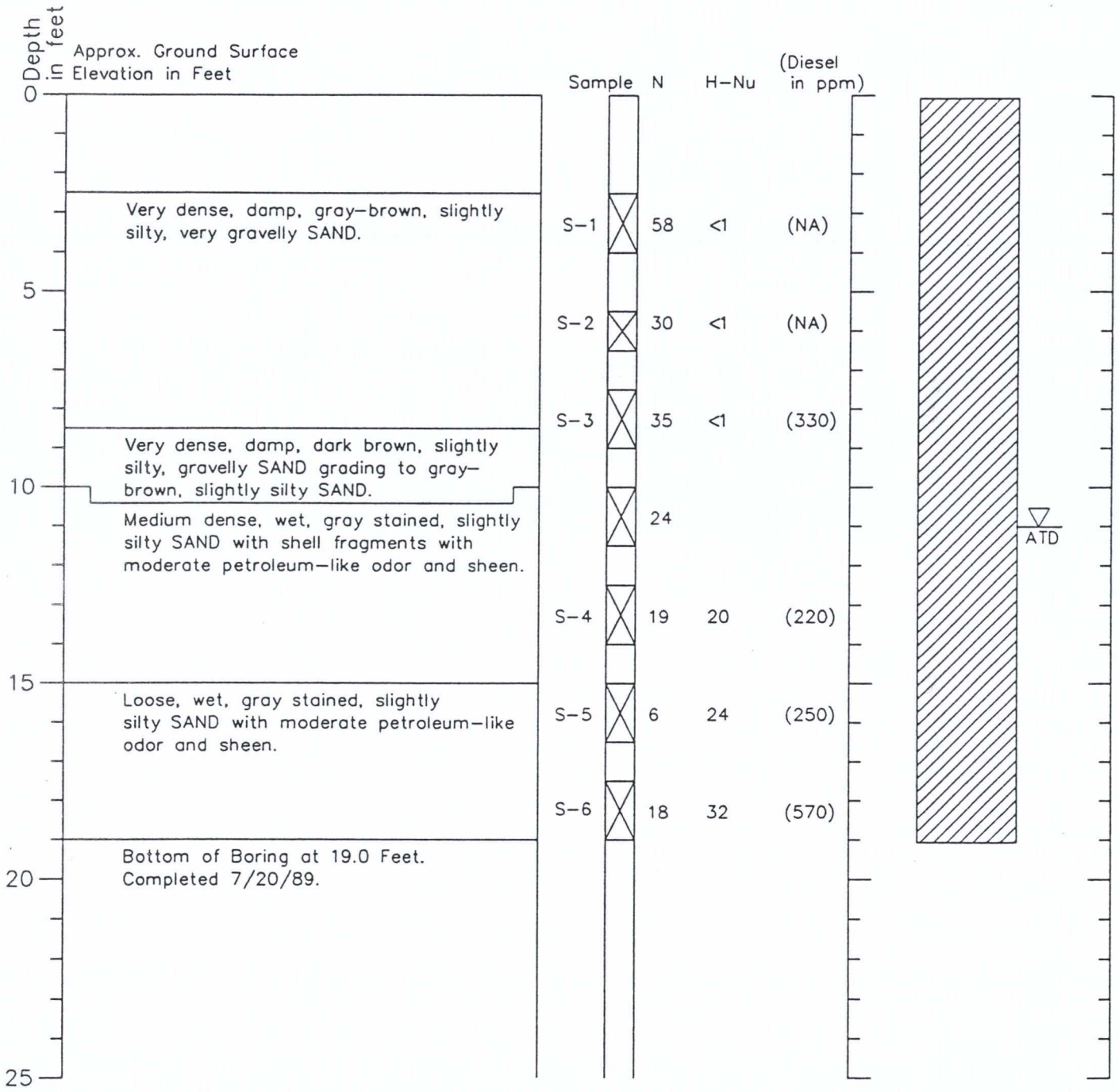
Figure 10

Boring Log B-9

Geologic Log



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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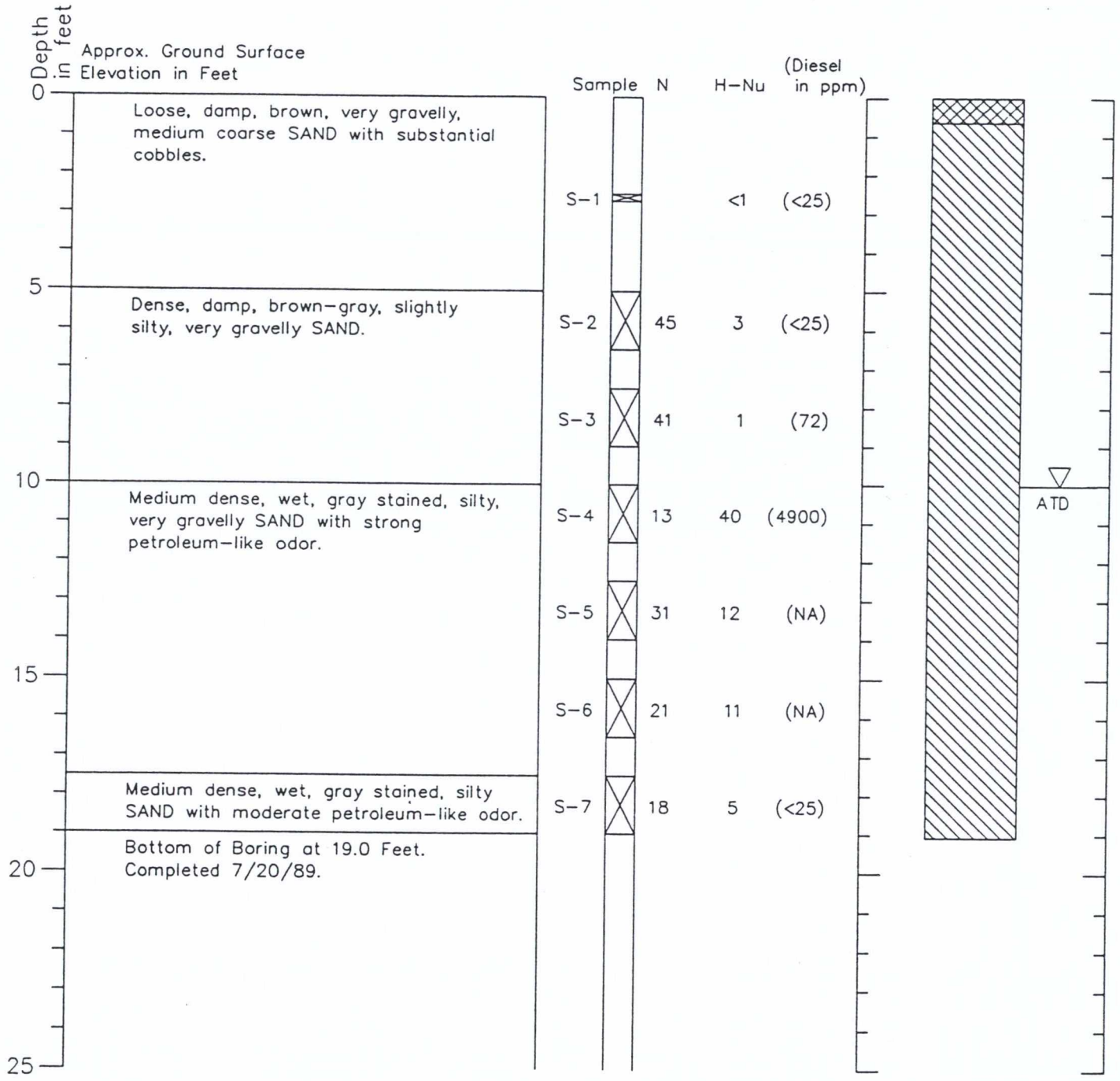
Figure 11

Boring Log B-10

Geologic Log



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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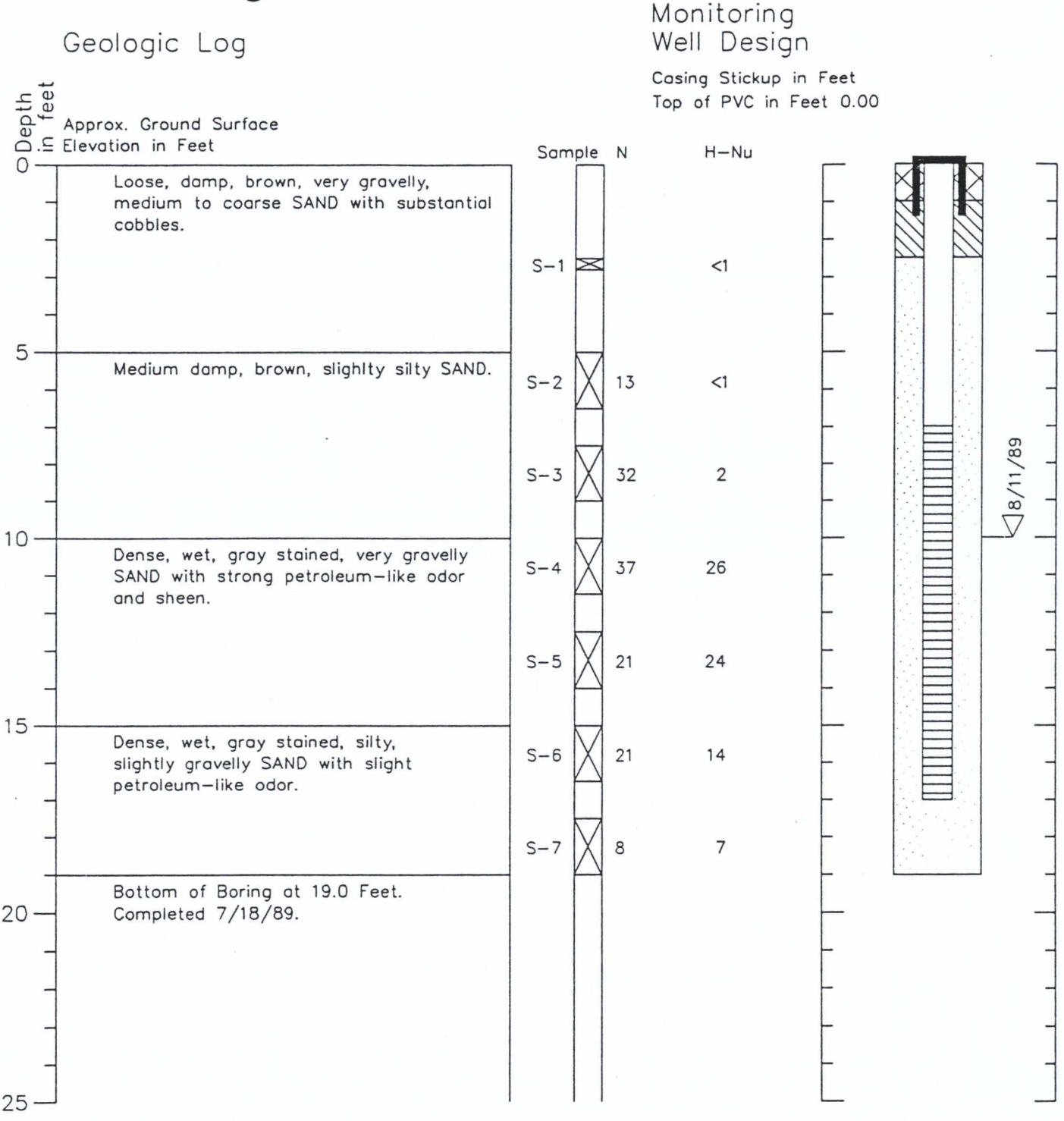
Figure 12

Boring Log and Construction Data for Monitoring Well B-11



1. Refer to Figure 2 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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Figure 13

Appendix B

APPENDIX B

WELL DEVELOPMENT AND GROUNDWATER SAMPLING

Well Development

All wells were developed/purged utilizing Teflon bailers. Between 30 to 50 gallons of water were removed from the 4-inch monitoring wells and 15 to 17.5 gallons were removed from the 2-inch monitoring wells. Purging was determined complete once the in-situ field parameters of pH, conductivity and temperature stabilized. All purge water was containerized in 55-gallon drums. Figures B-1 through B-12 present the monitoring well purge and sample data.

Groundwater Sampling

On December 6 and 7, 1989, following well development, Converse personnel collected groundwater samples from the newly installed 4-inch monitoring wells (MW-101, MW-102, MW-103 and MW-104) and from the 2-inch monitoring wells (MW-2, MW-3, MW-6, and MW-11) previously installed by Hart Crowser. The measuring point elevation for each of the 4-inch wells was surveyed on December 6, 1989 using a Port of Seattle benchmark located at the base of an abutment for the Garfield Street Bridge, west of the guard station. The 2-inch monitoring wells were surveyed on November 6, 1989 during the preliminary hydrogeologic assessment. The measuring points were marked in indelible ink on the north lip of the monitoring well. Groundwater levels were measured to the nearest 0.01 foot with an interface probe prior to purging the monitoring wells. Table B-1 is a list of the groundwater elevations for measurements taken on December 6, 1989.

TABLE B-1
GROUNDWATER MEASUREMENTS
December 6, 1989
Pacific Northern Oil, Terminal 91

Monitoring Well	Measuring Point Elevation (feet)	Groundwater Level (feet)	Groundwater Elevation (feet)
MW-101	17.55	7.06	10.49
MW-102	17.50	8.69	8.81
MW-103	17.43	8.98	8.45
MW-104	17.46	6.51	10.95
MW-2	17.95	8.35	9.60
MW-3	17.70	8.58	9.12
MW-6	18.06	8.57	9.49
MW-11	18.07	8.61	9.46

Petroleum odors were observed from the purge water of all eight monitoring wells. An oily sheen was observed floating on the purge water from MW-101, MW-104, MW-2, MW-3, MW-6 and MW-11. Free product was measured in MW-3 and MW-104. The thickness of product floating on the water table at MW-3 and MW-104 was 0.24 and 0.01 foot, respectively, on December 6, 1989.

A Teflon bailer was used for sample collection. Two 1-liter amber glass bottles that were obtained from the analytical laboratory were filled from each well. These bottles were then refrigerated for transport to Laucks Testing Laboratories. Chain-of-custody forms were completed to document sample collection and relinquishment. Appropriate analytical procedures were also specified on the chain-of-custody form. Water samples were analyzed for total petroleum hydrocarbons using EPA method 418.1. Bailers utilized for purging and sampling were thoroughly decontaminated between sampling locations. Bailers were scrubbed inside and outside with a Liquinox wash followed by a potable water rinse, methanol rinse and a distilled water rinse.

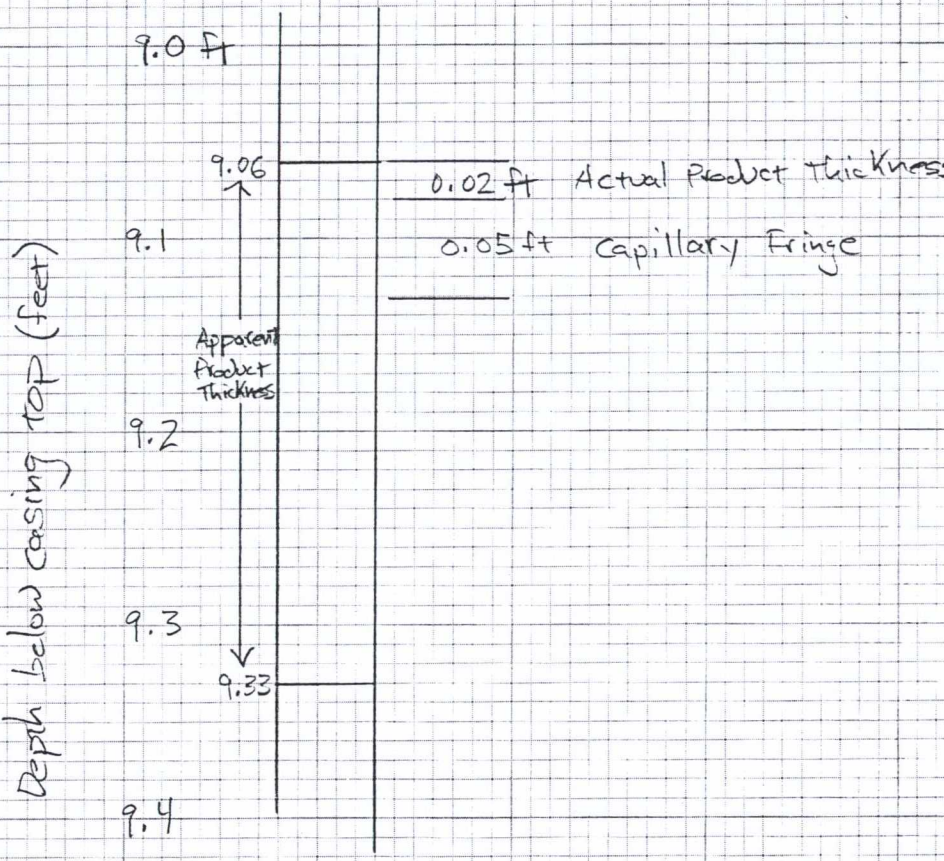
BY _____ DATE _____ CLIENT _____ SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ PROJECT NO. 89-45527-01

PROJECT _____

PNOCO Calculation Brief

	Product	Water	Water/Product Interface	Corrected Water Level
Inflection Point	9.12	9.14	0.02	9.13
Static	9.06	9.33	0.27	9.13



Monitor Well MW-3
Recovery Test Performed 10/30/89

FIGURE NO. D-2

Converse GES

SIGNED _____

REG. NO. _____

SHEET NO.

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: Pacific Northern Oil JOB NO: 89-45527-01 DATE: 10/30/89

WELL NO. MW-11 LOCATION: Terminal 91

WEATHER CONDITIONS: Cloudy AMBIENT TEMP: ____ TESTER'S INITIALS: EM/DY

PURGING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? Alconox wash/tap rinse/methanol/DI

How was the line decontaminated? ____

Which well was previously purged? None

SAMPLING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? Alconox wash/tap rinse/methanol/DI

How was the line decontaminated? ____

Which well was previously sampled? ____

INITIAL WELL VOLUME

Well diameter (in.) 2

Stickup (ft.) ____

Depth to bottom of well (ft.) 17.0

Depth to water surface (ft.) 9.32

Length of water (ft.) 7.98

Volume of water (ft^3) ~~1.3~~

(gal.) 1.3

Amount of sediment at bottom of well (ft.) ____

PURGING

Time started 11:25 finished 11:55

Volume purged 5 gal

Comments on Well Recovery ____

Additional Comments Sheen on water; water turbid.

Samples Collected: Start 11:55

Finish ____

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	0.7	2	5				
Turbidity							
Odor							
OVA (ppm)							
pH (units)	7.7	8.76	8.7				
Conductivity (μ mhos)	1500	1700	2000				
Water Temperature (°C)	17.4	17.7	17.7				
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: Pacific Northern Oil JOB NO: 89-45527-01 DATE: 10/30/89

WELL NO. MW-~~5~~6 LOCATION: Terminal 91

WEATHER CONDITIONS: cloudy AMBIENT TEMP: ____ TESTER'S INITIALS: EM/DY

PURGING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? Alconox wash/tap rinse/methanol/DI

How was the line decontaminated? ____

Which well was previously purged? MW-11

SAMPLING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? Alconox wash/tap rinse/methanol/DI

How was the line decontaminated? ____

Which well was previously sampled? MW-11

INITIAL WELL VOLUME

Well diameter (in.) 2

Stickup (ft.) ____

Depth to bottom of well (ft.) 17.42

Depth to water surface (ft.) 9.2

Length of water (ft.) ____

Volume of water (ft^3) 8

(gal.) 1.3

Amount of sediment at bottom of well (ft.) ____

PURGING

Time started 12:00 finished 12:20

Volume purged 7 gals.

Comments on Well Recovery ____

Additional Comments Sheen; Sample is cloudy

Samples Collected: Start ____ Finish ____

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	1	3	5	7			
Turbidity							
Odor							
OVA (ppm)							
pH (units)	8.76	9.07	9.22	9.05			
Conductivity (μ mhos)	900	850	950	950			
Water Temperature (°C)	17.6	17.5	17.7	17.6			
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: Pacific Northern Oil JOB NO: 89-45527-01 DATE: 10/30/89

WELL NO. MW-2 LOCATION: Terminal 91

WEATHER CONDITIONS: Cloudy AMBIENT TEMP: _____ TESTER'S INITIALS: ETH/DY

PURGING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? Alconox wash/tap rinse/methanol/DI

How was the line decontaminated? _____

Which well was previously purged? MW-6

SAMPLING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? (Same)

How was the line decontaminated? _____

Which well was previously sampled? MW-6

INITIAL WELL VOLUME

Well diameter (in.) 2

Stickup (ft.) _____

Depth to bottom of well (ft.) 17.35

Depth to water surface (ft.) 8.92

Length of water (ft.) _____

Volume of water (ft^3) _____

(gal.) 1.3

Amount of sediment at bottom of well (ft.) _____

PURGING

Time started 12:30 finished 12:55

Volume purged 5 gal.

Comments on Well Recovery _____

Additional Comments Sample was very cloudy; sheen

Samples Collected: Start 12:56

Finish _____

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	1	3	5				
Turbidity							
Odor							
OVA (ppm)							
pH (units)	8.91	9.39	9.39				
Conductivity (μ mhos)	950	975	950				
Water Temperature (°C)	17.5	17.1	17.8				
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: Pacific Northern Oil JOB NO: 89-45527-01 DATE: 10/30/89

WELL NO. MW-3 LOCATION: Terminal 91

WEATHER CONDITIONS: Cloudy AMBIENT TEMP: ____ TESTER'S INITIALS: EM/DY

PURGING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? Alconox wash/tap rinse/methanol/DI

How was the line decontaminated? ____

Which well was previously purged? MW-2

SAMPLING DEVICE

Type Device? Teflon bailer

How was the device decontaminated? (same)

How was the line decontaminated? ____

Which well was previously sampled? MW-2

INITIAL WELL VOLUME

Well diameter (in.) 2

Stickup (ft.) ____

Depth to bottom of well (ft.) 16.66

Depth to water surface (ft.) 9.08

Length of water (ft.) ____

Volume of water (ft^3) ____

(gal.) 1.2

Amount of sediment at bottom of well (ft.) ____

PURGING

Time started 1:00 finished 1:50

Volume purged 6 gals.

Comments on Well Recovery Able to bail all product off

Additional Comments Water is clear with suspended oil globuks.

Samples Collected: Start 1:55

Finish ____

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)							
Turbidity							
Odor							
OVA (ppm)							
pH (units)							
Conductivity (μ mhos)							
Water Temperature (°C)							
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHER OIL JOB NO: 89-45527-01 DATE: 12/7/89

WELL NO. MW-101 LOCATION: TERMINAL 91

WEATHER CONDITIONS: CLOUDY AMBIENT TEMP: 50 TESTER'S INITIALS: JS/RL

PURGING DEVICE

Type Device? PVC 4" BAILER

How was the device decontaminated?
ALCONX WASH/RINSE/METHNOL/DI

How was the line decontaminated?

Which well was previously purged? MW-2

SAMPLING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated?
ALCONX WASH/RINSE/METHNOL/DI

How was the line decontaminated?

Which well was previously sampled? MW-2

INITIAL WELL VOLUME

Well diameter (in.) 4"

Stickup (ft.)

Depth to bottom of well (ft.) 16.3

Depth to water surface (ft.) 7.06

Length of water (ft.) 9.24

Volume of water (ft^3)

(gal.) 6.02 x 3 = 18.07

Amount of sediment at bottom of well (ft.)

PURGING

Time started 1:00 finished 2:00

Volume purged 50 GAL

Comments on Well Recovery

Additional Comments
DISTINCT SCHEEN
FUEL ODOR

Samples Collected: TPH 418.1

Start 2:00
Finish 2:10

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	5	10	15	20	30	40	50
Turbidity	VERY	VERY	VERY	VERY	VERY	VERY	VERY
Odor	FUEL	FUEL	FUEL	FUEL	FUEL	FUEL	FUEL
OVA (ppm)							
pH (units)	6.98	6.69	6.71	6.75	6.71	6.70	6.6
Conductivity (μ mhos)	1940	1950	1950	1942	1985	1985	2110
Water Temperature (°C °F)	60.6	60.9	60.9	61	61.1	61.1	61.1
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.
Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHERN OIL JOB NO: 89-45527-01 DATE: 12/6/89

WELL NO. MW-10Z LOCATION: TERMINAL 91

WEATHER CONDITIONS: CLOUDY AMBIENT TEMP: 50 TESTER'S INITIALS: JS/RL

PURGING DEVICE	SAMPLING DEVICE
Type Device? TEFLON BAILER	Type Device? TEFLON BAILER
How was the device decontaminated? ALCONOX WASH/RINSE/METHNOL/DI	How was the device decontaminated? ALCONOX WASH/RINSE/METHNOL/DI
How was the line decontaminated?	How was the line decontaminated?
Which well was previously purged? MW 6	Which well was previously sampled? MW 6

INITIAL WELL VOLUME

Well diameter (in.) 4"

Stickup (ft.)

Depth to bottom of well (ft.) 17.2

Depth to water surface (ft.) 8.69

Length of water (ft.) 8.51

Volume of water (ft^3)

(gal.) 5.55 x 3 = 16.65

Amount of sediment at bottom of well (ft.)

PURGING

Time started 2:15 finished 3:26

Volume purged 30 GAL

Comments on Well Recovery

Additional Comments SLIGHT FUEL ODOR

Samples Collected: TPH 418.1

Start 3:30

Finish 3:35

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	5	10	15	20	25	30	
Turbidity	VERY	VERY	VERY	VERY	CLOUDY	CLOUDY	
Odor	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	
OVA (ppm)							
pH (units)	6.71	6.64	6.53	6.50	6.49	6.45	
Conductivity (μ mhos)	1445	1450	1450	1355	1430	1385	
Water Temperature (~~°C~~) °F	61.3	61.5	61.6	61.5	61.6	61.6	
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHERN OIL JOB NO: 89-45527-01 DATE: 12/6/89

WELL NO. MW-103 LOCATION: TERMINAL 91

WEATHER CONDITIONS: CLOUDY AMBIENT TEMP: 50 TESTER'S INITIALS: JS/RL

PURGING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONOX WASH/RINSE/METHNOL/DI

How was the line decontaminated?

Which well was previously purged? MW-102

SAMPLING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONOX WASH/RINSE/METHNOL/DI

How was the line decontaminated?

Which well was previously sampled? MW-102

INITIAL WELL VOLUME

Well diameter (in.) 4"

Stickup (ft.)

Depth to bottom of well (ft.) 17.01'

Depth to water surface (ft.) 8.98'

Length of water (ft.) 8.03

Volume of water (ft^3)

(gal.) 5.24 x 3 = 15.71

Amount of sediment at bottom of well (ft.)

PURGING

Time started 3:50 finished 4:46

Volume purged 30 GAL

Comments on Well Recovery

Additional Comments SLIGHT FUEL ODOR

Samples Collected: TPH 418.1 Start 4:50 Finish 5:06

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	5	10	15	20	25	30	
Turbidity	VERY	VERY	VERY	CLOUDY	CLOUDY	CLOUDY	
Odor	FUEL SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	
OVA (ppm)							
pH (units)	6.4	6.30	6.27	6.34	6.31	6.46	
Conductivity (μ mhos)	1355	1340	1335	1335	1326	1310	
Water Temperature (~~oC~~ °F	61.6	61.6		61.6	61.6	61.3	
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHERN OIL JOB NO: 89-45527-01 DATE: 12/7/89

WELL NO. MW-104 LOCATION: TERMINAL 91

WEATHER CONDITIONS: CLOUDY AMBIENT TEMP: 50 TESTER'S INITIALS: JS/RL

PURGING DEVICE

Type Device? PVC 4" BAILER

How was the device decontaminated? ALCONOX WASH/RINSE/METHANOL/DI

How was the line decontaminated?

Which well was previously purged? MW-101

SAMPLING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONOX WASH/RINSE/METHANOL/DI

How was the line decontaminated?

Which well was previously sampled? MW-101

INITIAL WELL VOLUME

Well diameter (in.) 4"

Stickup (ft.)

Depth to bottom of well (ft.) 17.4

Depth to water surface (ft.) 6.50 PRODUCT 5.52 WATER

Length of water (ft.) 10.88

Volume of water (ft^3)

(gal.) 7.09 x 3 = 21.28

Amount of sediment at bottom of well (ft.)

PURGING

Time started 2:15 finished 3:10

Volume purged 50 GAL

Comments on Well Recovery

Additional Comments FUEL ODOR
DISTINCT SHEEN
0.01' FLOATING PRODUCT

Samples Collected: TPH 418.1

Start 3:15

Finish 3:25

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	10	20	30	40	50		
Turbidity	VERY	VERY	VERY	VERY	VERY		
Odor	FUEL	FUEL	FUEL	FUEL	FUEL		
OVA (ppm)							
pH (units)	6.47	6.25	6.58	6.46	6.46		
Conductivity (μ mhos)	1100	1100	1103	1160	1150		
Water Temperature (cel °F)	60.4	60.6	60.5	60.6	60.5		
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHERN OIL JOB NO: 89-45527-01 DATE: 12/7/89

WELL NO. MW-2 LOCATION: TERMINAL 91

WEATHER CONDITIONS: CLOUDY AMBIENT TEMP: 50°F TESTER'S INITIALS: IS/RL

PURGING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONX WASH/RINSE/METHNOL/DI

How was the line decontaminated?

Which well was previously purged? MW-11

SAMPLING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONX WASH/RINSE/METHNOL/DI

How was the line decontaminated?

Which well was previously sampled? MW-11

INITIAL WELL VOLUME

Well diameter (in.) 2"

Stickup (ft.)

Depth to bottom of well (ft.) 17.30

Depth to water surface (ft.) 8.35

Length of water (ft.) 8.95

Volume of water (ft^3)

(gal.) 1.46x3 = 4.38

Amount of sediment at bottom of well (ft.)

PURGING

Time started 11:00 finished 11:37

Volume purged 17.5GAL

Comments on Well Recovery

Additional Comments FUEL ODOR SLIGHT SCHEEN

Samples Collected: TPH 418.1 Start 11:40 Finish 11:46

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	2.5	5	7.5	10	12.5	15	17.5
Turbidity	VERY	CLOUDY	CLOUDY	CLOUDY	CLOUDY	CLOUDY	VERY
Odor	FUEL	FUEL	FUEL	FUEL	FUEL	FUEL	FUEL
OVA (ppm)							
pH (units)	6.23	6.28	6.35	6.41	6.49	6.50	6.58
Conductivity (μ mhos)	1004	1000	986	975	970	972	970
Water Temperature (cel °F	61.3	61.4	61.5	61.4	61.5	61.6	61.5
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.
Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHERN OIL JOB NO: 89-45527-01 DATE: 12/7/89

WELL NO. MW-7 LOCATION: TERMINAL 91

WEATHER CONDITIONS: CLOUDY AMBIENT TEMP: 50 TESTER'S INITIALS: JS/RL

PURGING DEVICE

Type Device? PRODUCT BAILER THEN TEFLON BAILER

How was the device decontaminated? ALCONOX WASH / RINSE / METHANOL / DI

How was the line decontaminated?

Which well was previously purged? MW-104

SAMPLING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONOX WASH / RINSE / METHANOL / DI

How was the line decontaminated?

Which well was previously sampled? MW-104

INITIAL WELL VOLUME

Well diameter (in.) 2"

Stickup (ft.)

Depth to bottom of well (ft.) 16.55

Depth to water surface (ft.) 8.76 PRODUCT

Length of water (ft.) 7.79

Volume of water (ft^3)

(gal.) 1.26×3=3.81

Amount of sediment at bottom of well (ft.)

PURGING

Time started 3:35 finished 4:10

Volume purged 15 GAL

Comments on Well Recovery

Additional Comments FUEL ODOR

0.25' FLOATING PRODUCT

SCHEEN

Samples Collected: TPH 418.1

Start 4:15

Finish 4:20

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	2.5	5	7.5	10	12.5	15	
Turbidity	CLOUDY	CLOUDY	CLOUDY	CLOUDY	CLOUDY	CLOUDY	
Odor	FUEL	FUEL	FUEL	FUEL	FUEL	FUEL	
OVA (ppm)							
pH (units)	6.27	6.27	6.27	6.26	6.24	6.29	
Conductivity (μ mhos)	1070	1120	1090	1080	1090	1090	
Water Temperature per °F	61.7	62	62	62	61.9	61.9	
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHERN OIL JOB NO: 89-45527-01 DATE: 12/6/89

WELL NO. MW-6 LOCATION: TERMINAL 91

WEATHER CONDITIONS: CLOUDY AMBIENT TEMP: 50 TESTER'S INITIALS: JS/RL

PURGING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONOX / RINSE / METHANOL / DI

How was the line decontaminated?

Which well was previously purged? NONE 1ST WELL

SAMPLING DEVICE

Type Device? TEFLON BAILER

How was the device decontaminated? ALCONOX / RINSE / METHANOL / DI

How was the line decontaminated?

Which well was previously sampled? NONE 1ST WELL

INITIAL WELL VOLUME

Well diameter (in.) 2"

Stickup (ft.)

Depth to bottom of well (ft.) 17.4

Depth to water surface (ft.) 8.57

Length of water (ft.) 8.83

Volume of water (ft^3)

(gal.) 1.44 x 3 = 4.32

Amount of sediment at bottom of well (ft.)

PURGING

Time started 1:07 finished 2:00

Volume purged 15 GAL

Comments on Well Recovery

Additional Comments

FUEL ODOR STRONG

SCHEEN ON WATER SURFACE

Samples Collected: TPH 418.1

Start 2:02

Finish 2:15

IN-SITU TESTING

	1	2	3	4	5	6	7
Well Volume Purged (gal)	2.5	5.0	7.5	10	12.5	15	
Turbidity	CLOUDY	CLOUDY	CLOUDY	SOMEWHAT	SOMEWHAT	SOMEWHAT	
Odor	FUEL/SCHEEN	FUEL/SCHEEN	FUEL	FUEL	FUEL	FUEL	
OVA (ppm)							
pH (units)	6.19	6.23	6.2	6.21	6.34	6.16	
Conductivity (μ mhos)	105	40	50	23	980	20	— ?
Water Temperature (Cel or °F)	62.9	63.1	63.2	63.2	63.2	63.2	
TDS (mg/L)							

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

SUMMARY SHEET FOR WATER SAMPLING

PROJECT NAME: PACIFIC NORTHERN OIL JOB NO: 89-45527-01 DATE: 12/7/89

WELL NO. MW-11 LOCATION: TERMINAL 91

WEATHER CONDITIONS: OVERCAST AMBIENT TEMP: ____ TESTER'S INITIALS: JS

PURGING DEVICE TEFLON

Type Device? BAILER

How was the device decontaminated? ALCONX WASH / RINSE / METHNOL / DI

How was the line decontaminated? ____

Which well was previously purged? 12/6/89 MW-103

SAMPLING DEVICE TEFLON

Type Device? BAILER

How was the device decontaminated? ALCONX WASH / RINSE / METHNOL / DI

How was the line decontaminated? ____

Which well was previously sampled? MW-103

INITIAL WELL VOLUME

Well diameter (in.) 2"

Stickup (ft.) ____

Depth to bottom of well (ft.) 16.85

Depth to water surface (ft.) 8.61

Length of water (ft.) 8.24

Volume of water (ft^3) ____

(gal.) 1.34 x 3 = 4.03

Amount of sediment at bottom of well (ft.) ____

PURGING

Time started 9:30 finished 10:30

Volume purged 17.5 GAL

Comments on Well Recovery ____

Additional Comments SLIGHT SHEEN / SLIGHT ODOR

Samples Collected: TPH 418.1

Start 10:40

Finish 10:45

IN-SITU TESTING

		1	2	3	4	5	6	7
Well Volume Purged (gal)		2.5	5.0	7.5	10	12.5	15	17.5
Turbidity		VERY	VERY	VERY	VERY	VERY	CLOUDY	CLOUDY
Odor	FUEL	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT
OVA (ppm)								
pH (units)		6.44	6.65	6.52	6.63	6.48	6.46	7.2
Conductivity (μ mhos)		1790	2090	2110	2260	2250	2150	2150
Water Temperature (circled) °F		60.8	61	61.0	61.1	61.2	61.2	60.8
TDS (mg/L)								

NOTES: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length of 2" = 0.022 ft^3 or 0.16 gal.

Turbidity choices: clear, turbid, opaque

Appendix C

APPENDIX C

CHAIN-OF-CUSTODY DOCUMENTATION AND LABORATORY REPORT ANALYTICAL RESULTS

Laucks
Testing Laboratories, Inc.
940 South Harney St., Seattle, Washington 98108 (206) 767-5060 FAX 767-5063

Chemistry, Microbiology, and Technical Services

Converse Consultants NW
3131 Elliott Ave West, #550
Seattle, WA 98121

Attn: Erick Miller

Work ID: Pacific Northern
P O # : Job No. 89-45527-02

Date Received: 10/30/89
Date Reported: 11/06/89
Work Order: 89-10-233
Category: 1184008

Test	Units	MW11 Southwest Corner 10/30/89 11:39	MW6 Center Well 10/30/89 12:20	MW2 North Well 10/30/89 12:56	MW3 Southeast Well 10/30/89 01:44
TPH (Method EP 418.1)	mg/L	7.4	13.	15.	730.

Certified By: J. M. Quinn

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REPORT ON WORK ORDER 8910233 PREPARATION BLANKS

Test	: TPH (Method EP 418.1)		
Blank Name	: B1101OGW01	Preparation Date:	11/01/89
Conc Found	: 0.500 U	Control Limit :	1.000
Units	: mg/L		

This blank and comments, if any, apply to the following sample(s):
1-4

* = outside control limits
U = analtye not detected

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CHAIN OF CUSTODY RECORD

DATE 10/30/89 PAGE 1 OF 1

NAME ~~Ext.~~ Converse GES
ADDRESS 3131 Elliott Avenue
Suite 550
ATTENTION: Erick Miller
PROJECT NAME Pacific Northern
JOB/P.O. NO. 89-45527-02
SAMPLER (SIGNATURE) Erick Miller (PRINTED NAME) Erick Miller

TESTING PARAMETERS: TPH (418.1)

LAB NO.	LAB SA #	SAMPLE NO.	DATE	TIME	LOCATION	NO. OF CONTAINERS	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS
		MW11	10-30-89	11:39	South West Corner	2	
		MW6	"	12:20	Center Well	2	
		MW2	"	12:56	North Well	2	
		MW3	"	1:55	Southeast Well	2	

RELINQUISHED BY
David A. Yonemitsu
SIGNATURE
DAVID A. YONEMITSU
PRINTED NAME
CONVERSE Consultants
COMPANY
DATE 10/30/89
TIME 3058

RECEIVED BY
SIGNATURE
PRINTED NAME
COMPANY
DATE
TIME

RELINQUISHED BY
SIGNATURE
PRINTED NAME
COMPANY
DATE
TIME

RECEIVED BY
Lisa Molitor
SIGNATURE
Lisa Molitor
PRINTED NAME
LAUCKS TESTING LABS
COMPANY
DATE 10/30/89
TIME 3:05

TOTAL NUMBER OF CONTAINERS:

SHIPMENT METHOD:

SPECIAL SHIPMENT, HANDLING OR STORAGE REQUIREMENTS:

INSTRUCTIONS:
1. Shaded areas for lab use only.
2. Complete in ballpoint pen. Draw one line through errors and initial.
3. Be specific in test requests.
4. Check off tests to be performed for each sample.
5. Retain final copy after signing.
6. Provide name and telephone of your contact person.

NAME
TELEPHONE

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CLIENT: Converse Consultants NW
3131 Elliot Ave West, Suite 550
Seattle, WA 98121
ATTN: John J. Strunk

LABORATORY NO. 89-12-001

DATE: Jan. 2, 1990

PO# 89-45527-01

REPORT ON: SOIL

SAMPLE IDENTIFICATION: Submitted 12/01/98 and identified as shown below:

1) MW-101 7.5' - 10'
2) MW-101 10' - 12.5'
3) MW-101 12.5'- 15'
4) MW-103 7.5' - 10'
5) MW-103 10' - 12.5'
6) MW-103 12.5'- 15'
7) MW-102 7.5' - 10'
8) MW-102 10' - 12.5'
9) MW-102 12.5'- 15'
10) MW-104 7.5' - 10'
11) MW104 10' - 12.5'
12) MW104 12.5' - 15'

TESTS PERFORMED AND RESULTS:

Sample was passed through a No. 10 sieve, with percent retained and description of retained matter shown below. Only material passing the sieve was analyzed.

Sample No.	% Retained	Major Description	Minor Description
1	61	Rock	---
2	46	Rock	---
3	58	Rock	---
4	65	Rock	---
5	50	Rock	---
6	12	Rock	---
7	64	Rock	---
8	17	Rock	---
9	<2	Rock	---
10	57	Rock	---
11	67	Rock	---
12	51	Rock	---

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Converse Consultants NW

LABORATORY NO. 89-12-001

PO# 89-45527-01

	1	2	3	4	5	6
Total Solids, %	84.2	80.4	80.8	93.2	83.7	79.7
	7	8	9	10	11	12
	88.3	80.3	80.8	82.6	80.8	82.2

parts per million (mg/kg) dry basis

	1	2	3	4	5	6
Total Petroleum Hydrocarbons Oil & Grease	4,600.	310.	<20.	4,700.	7,800.	47.
	7	8	9	10	11	12
	39,000.	17,000.	220.	9,000.	15,000.	200.

Method Blank

<20.

Key

< indicates "less than"

Respectfully submitted,

Laucks Testing Laboratories, Inc.

J. M. Owens

JMO:bv

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APPENDIX A

Matrix Spike/Matrix Spike Duplicate Report

parts per million (mg/L)

Sample	Analyte	Spike Level	Sample Result	MS Result	% Rec	MSD Result	% Rec	RPD	QC LIMITS RPD	QC LIMITS REC
3	OG	664.	<20.	574.	86	546.	82	5.	82-114	0-13

MS = Matrix Spike
MSD = Matrix Spike Duplicate
Rec = Recovery
RPD = Relative Percent Difference

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APPENDIX B

Copy of Chain-of-Custody is Attached

Converse GES Geoenvironmental Services

CHAIN OF CUSTODY RECORD

Project No.	Project Name
89-45527-01	PACIFIC NORTHERN OIL TERM 91

Samplers: (signature) John D Smith

	Station No.	Date	Time	Comp.	Grab	Station Location	Number of Containers	TPH EP 418.1 SOIL						Remarks
1	MW-101	11/29/89	10:36		✓	MW-101 7.5'-10'	1	✓						SOIL SAMPLES
2	MW101	11/29/89	10:43		✓	MW-101 10'-12.5'	1	✓						" "
3	MW101	11/29/89	10:55		✓	MW-101 12.5'-15'	1	✓						" "
4	MW103	11/29/89	2:45		✓	MW-103 7.5-10'	1	✓						" SAMPLE 89102001
5	MW103	11/29/89	3:06		✓	MW-103 10'-12.5'	1	✓						" "
6	MW103	11/29/89	3:17		✓	MW-103 12.5-15'	1	✓						" "
7	MW102	11/30/89	9:28		✓	MW-102 7.5'-10'	1	✓						" "
8	MW102	11/30/89	9:37		✓	MW-102 10'-12.5'	1	✓						" "
9	MW102	11/30/89	9:48		✓	MW-102 12.5'-15'	1	✓						" "
10	MW104	11/30/89	11:25		✓	MW-104 7.5'-10'	1	✓						" "
11	MW104	11/30/89	11:31		✓	MW 104 10'-12.5'	1	✓						" "
12	MW104	11/30/89	11:40		✓	MW 104 12.5'-15'	1	✓						" "

Relinquished by: (signature) John Smith	Date/Time 11/30/89 2:46PM	Received by: (signature)
Relinquished by: (signature)	Date/Time	Received by: (signature)
Relinquished by Courier: (signature)	Date/Time	Received by Mobile Lab: (signature)
Method of Shipment		Shipped by: (signature)

Relinquished by: (signature)	Date/Time	Received by: (signature)
Relinquished by: (signature)	Date/Time	Received by: (signature)
Relinquished by Mobile Lab: (signature)	Date/Time	Received by Courier: (signature)
Courier from Airport: (signature)	Received for Laboratory: (signature)	Date/Time

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Chemistry, Microbiology, and Technical Services

CLIENT: Converse Consultants NW
3131 Elliot Ave West, Suite 550
Seattle, WA 98121
ATTN: John Strunk/Erick Miller

LABORATORY NO. 89-12-066

DATE: Jan. 2, 1990

PO# 89-45527-01

REPORT ON: WATER

SAMPLE IDENTIFICATION: Submitted 12/07/89 and identified as shown below:

1) MW-101 PNO
2) MW-102 PNO
3) MW-103 PNO
4) MW-104 PNO
5) MW-2 PNO
6) MW-3 PNO
7) MW-6 PNO
8) MW-11 PNO

TESTS PERFORMED AND RESULTS:

parts per million (mg/L)

	1	2	3	4	5
Total Petroleum Hydrocarbons Oil & Grease	28.	6.9	6.9	6.2	3.0

	6	7	8	Method Blank
	52.	2.8	<0.5	<0.5

Key

< indicates "less than"

Respectfully submitted,

Laucks Testing Laboratories, Inc.

J. M. Owens

JMO:bv

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APPENDIX A

Matrix Spike/Matrix Spike Duplicate Report

parts per million (mg/L)

Sample	Analyte	Spike Level	Sample Result	MS Result	% Rec	MSD Result	% Rec	RPD	QC LIMITS RPD	QC LIMITS REC
8	OG	107.4	0.	86.	80%	85.	79%	174-126	0-11	

MS = Matrix Spike
MSD = Matrix Spike Duplicate
Rec = Recovery
RPD = Relative Percent Difference

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APPENDIX B

Copy of Chain-of-Custody is Attached

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940 South Harney St. Seattle, Washington 98108 (206)767-5060

CHAIN OF CUSTODY RECORD

DATE 12/7/89 PAGE ____ OF ____

NAME: CONVERSE CONSULTANTS NW
ADDRESS: 3131 ELLIOTT AVE, SUITE 550
SEATTLE, WA 98121
ATTENTION: JOHN STRUNK
PROJECT NAME: PACIFIC NORTHERN OIL
JOB/P.O. NO.: 89-45527-01
SAMPLER (SIGNATURE): John Strunk (PRINTED NAME): JOHN STRUNK

SAM8912066

LAB NO.	LAB SA #	SAMPLE NO.	DATE	TIME	LOCATION	TESTING PARAMETERS: TPH 418.1	NO. OF CONTAINERS	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS
1		MW-101	12/7	2:00	PNO	✓	2	ANALYZE ONLY 1
2		MW-102	12/6	3:30	PNO	✓	2	SAMPLE CONTAINER
3		MW-103	12/6	4:50	PNO	✓	2	PER SITE.
4		MW-104	12/7	3:15	PNO	✓	2	THE 2ND CONTAINER
5		MW-2	12/7	11:40	PNO	✓	2	IS AN EXTRA
6		MW-3	12/7	4:15	PNO	✓	2	IN CASE OF
7		MW-6	12/6	2:02	PNO	✓	2	BROKEN CONTAINER
8		MW-11	12/7	10:40	PNO	✓	2	

RELINQUISHED BY	DATE	RECEIVED BY	DATE
SIGNATURE: John Strunk	12/7/89	SIGNATURE:	
PRINTED NAME: JOHN STRUNK	TIME: 4:57PM	PRINTED NAME:	TIME
COMPANY: CONVERSE CONSULTANTS NW		COMPANY:	
RELINQUISHED BY	DATE	RECEIVED BY	DATE
SIGNATURE:		SIGNATURE: Lisa Molitor	12/7/89
PRINTED NAME:	TIME	PRINTED NAME: Lisa Molitor	TIME: 4:57 pm.
COMPANY:		COMPANY: LAUCKS TESTING LABS	

TOTAL NUMBER OF CONTAINERS: 16

SHIPMENT METHOD:

SPECIAL SHIPMENT, HANDLING OR STORAGE REQUIREMENTS:

INSTRUCTIONS:
1. Shaded areas for lab use only.
2. Complete in ballpoint pen. Draw one line through errors and initial.
3. Be specific in test requests.
4. Check off tests to be performed for each sample.
5. Retain final copy after signing.
6. Provide name and telephone of your contact person.

NAME: ERICK MILLER
TELEPHONE: 285-5200

Appendix D

APPENDIX D

PRODUCT RECOVERY TEST

On October 30, 1989, a product recovery test was performed on the 2-inch diameter, monitoring well MW-3 based on a method presented by Gruszczenski, 1987[1]. All product was bailed from the well using a Teflon bailer and decanted into a 55-gallon drum. The rising water/product interface and top of product level was measured using an Oil Recovery Systems (ORS) interface probe. Results of the test are depicted graphically in Figure D-1.

Because the apparent product thickness is greater than the actual product thickness in the formation, then at some time during recovery of the product in the well, the product thickness in the well bore will equal the true product thickness. This point is the inflection point of the water/product interface measurements in Figure D-1. Results of the test indicate a true product thickness of less than a half inch. Results of the test are shown schematically in the calculation brief presented in Figure D-2. The true product thickness will be useful for estimating quantities of fugitive petroleum when the extent of the product lens is known.

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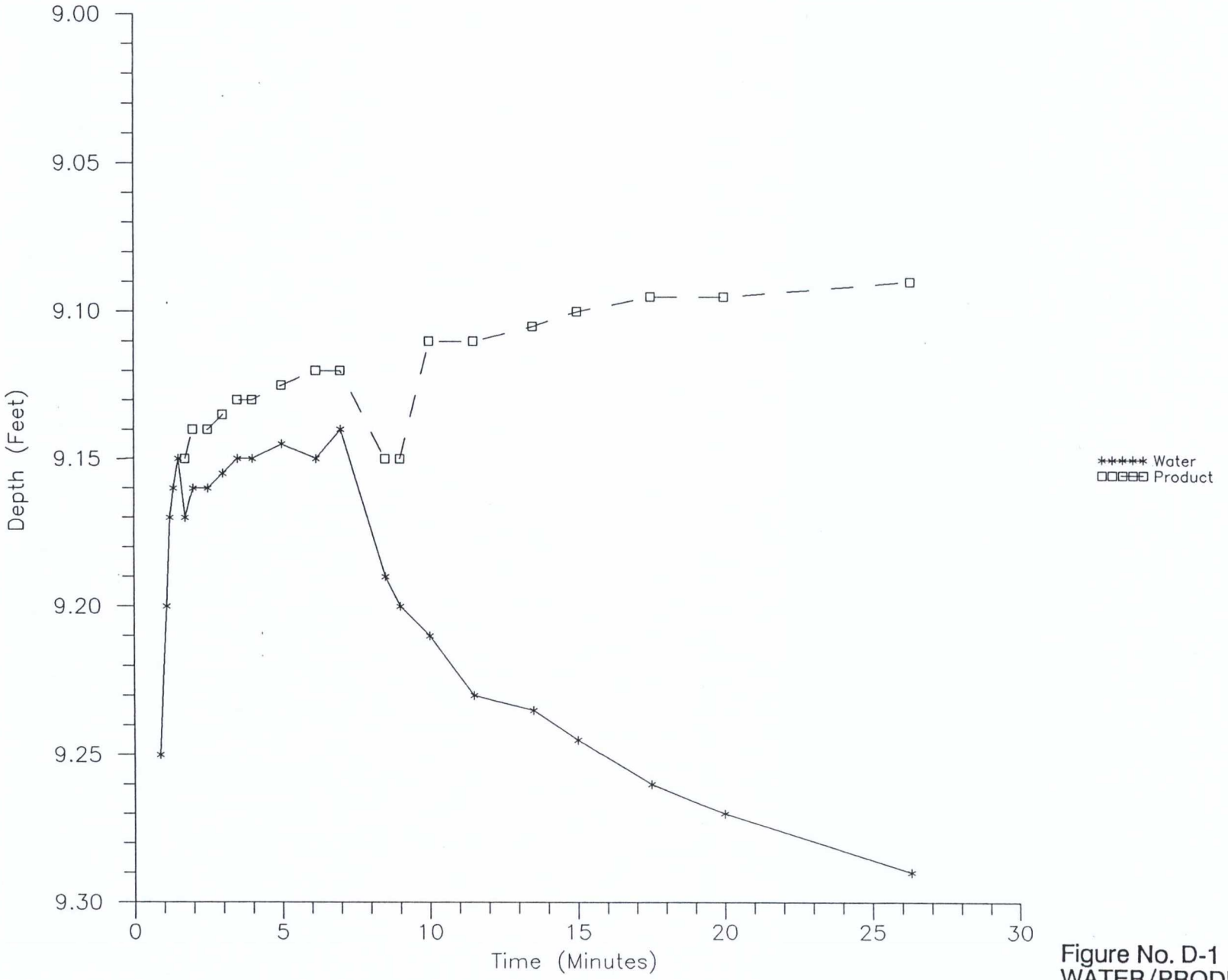
[1] Gruszczenski, T.S., 1987, Determination of a realistic estimate of the actual formation production thickness using monitoring wells - a field bailout test, in Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Restoration.



89-45527-01

Figure No. D-1
WATER/PRODUCT LEVELS VS. TIME
Pacific Northern Oil - Terminal 91